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1	BRS	L1	121	ion adj generator & brush	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/29 09:50
2	BRS	L2	36	ion adj generator & brush & corona adj discharge	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/10/29 09:32
3	IS&R	L3	125	(132/116).CCLS.	USPAT	2003/10/29 09:34
4	IS&R	L4	227	(132/112).CCLS.	USPAT	2003/10/29 09:34
5	IS&R	L5	339	(132/148).CCLS.	USPAT	2003/10/29 09:35
6	IS&R	L6	47	(132/152).CCLS.	USPAT	2003/10/29 09:35
7	IS&R	L7	42	(132/154).CCLS.	USPAT	2003/10/29 09:36
8	IS&R	L8	89	(132/271).CCLS.	USPAT	2003/10/29 09:37
9	IS&R	L9	59	(132/272).CCLS.	USPAT	2003/10/29 09:38
10	IS&R	L10	84	(607/79).CCLS.	USPAT	2003/10/29 09:39
11	IS&R	L11	168	(15/104.002).CCLS.	USPAT	2003/10/29 09:41
12	IS&R	L12	86	(15/246.3).CCLS.	USPAT	2003/10/29 09:41
13	IS&R	L13	581	(15/344).CCLS.	USPAT	2003/10/29 09:41

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15	IS&R	L15	18	(15/39.5).CCLS.	USPAT	2003/10/29 09:42
16	IS&R	L16	281	(15/40).CCLS.	USPAT	2003/10/29 09:46
17	IS&R	L17	408	(219/222).CCLS.	USPAT	2003/10/29 09:46

United States Patent [19]

Banks et al.

[11] **3,862,420**

[45] **Jan. 21, 1975**

[54] **SYSTEM TO PREVENT THE FORMATION OF PARTICULATE MATERIAL IN CORONA UNITS**

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[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[22] Filed: **Nov. 1, 1973**

[21] Appl. No.: **411,987**

[52] U.S. Cl. .... **250/324**, 317/262 A

[51] Int. Cl. **G03g 15/00**

[58] **Field of Search** .... 250/324, 325, 326; 317/262 A; 55/274, 275

[56] **References Cited**

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Primary Examiner—James W. Lawrence

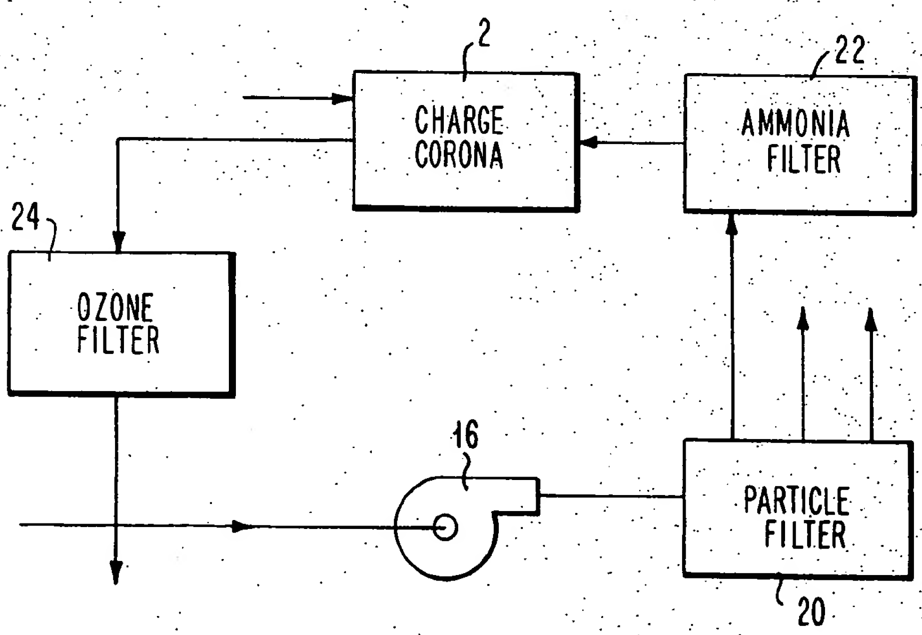
Assistant Examiner—C. E. Church

Attorney, Agent, or Firm—Otto Schmid, Jr.

[57] **ABSTRACT**

Apparatus is disclosed for supplying air to a corona discharge device to eliminate contamination within the corona unit and associated apparatus. Before introduction of the air into the corona device, the air is first passed through a particle filter to eliminate dust particles and then through an ammonia filter to prevent the formation of particulate material within the corona device. The ammonia filter contains a chemically active material to react with the ammonia in the air and apparatus is provided to sense end-of-life of the ammonia filter.

15 Claims, 5 Drawing Figures



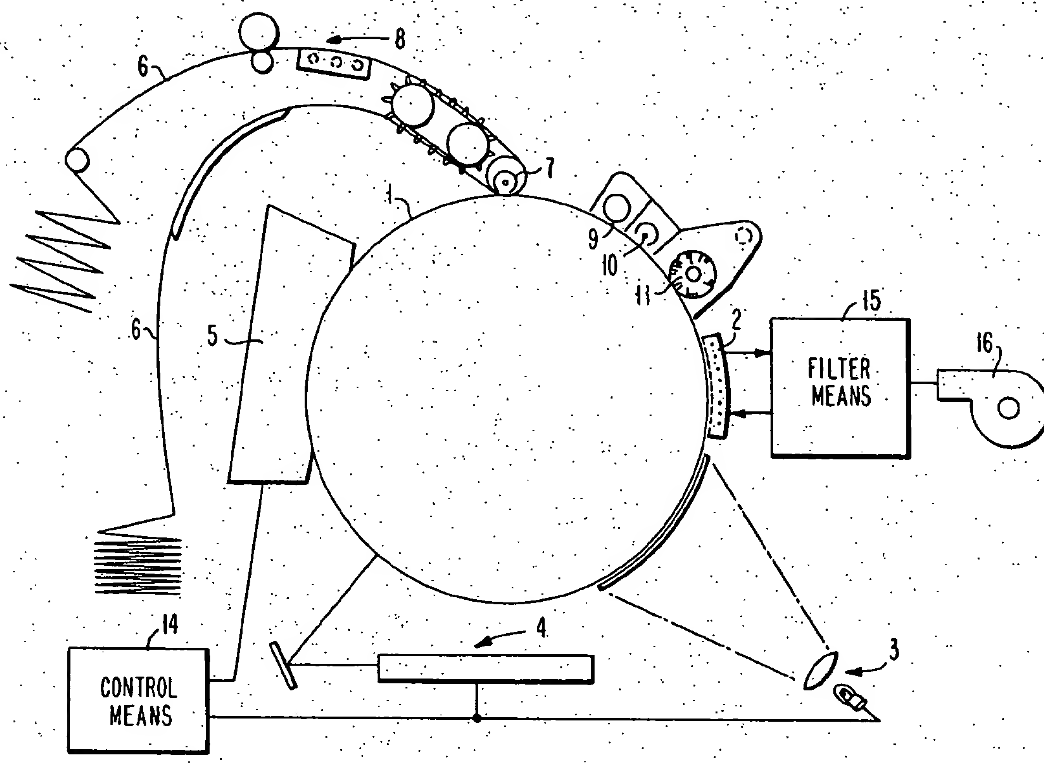

6
8
7
1
9
10
11
2
15
FILTER MEANS
16
6
5
14
CONTROL MEANS
4
3

FIG. 1

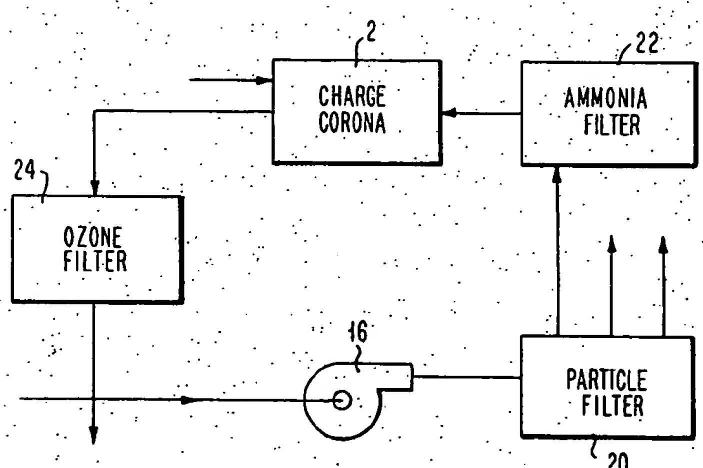

2
CHARGE CORONA
22
AMMONIA FILTER
24
OZONE FILTER
16
PARTICLE FILTER
20

FIG. 2

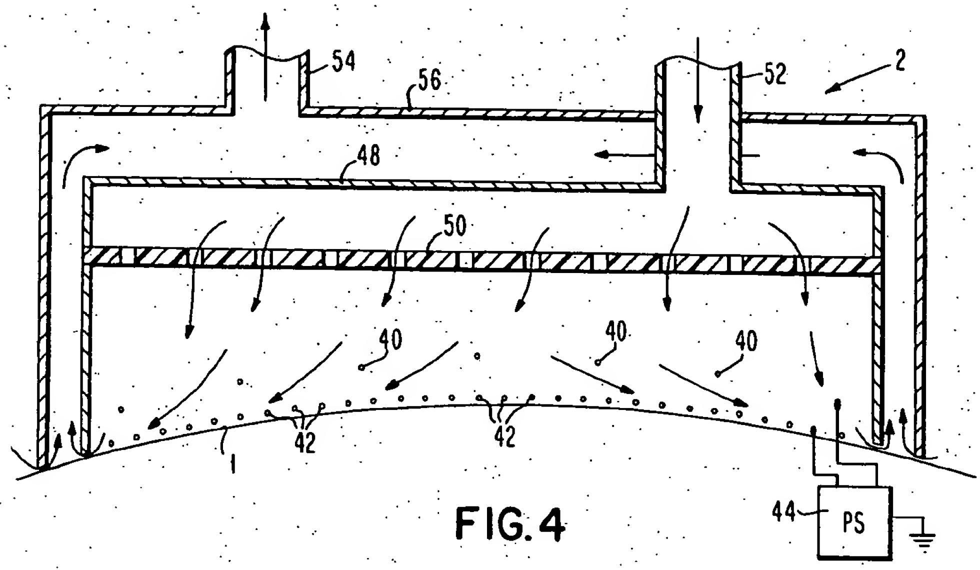


FIG. 4

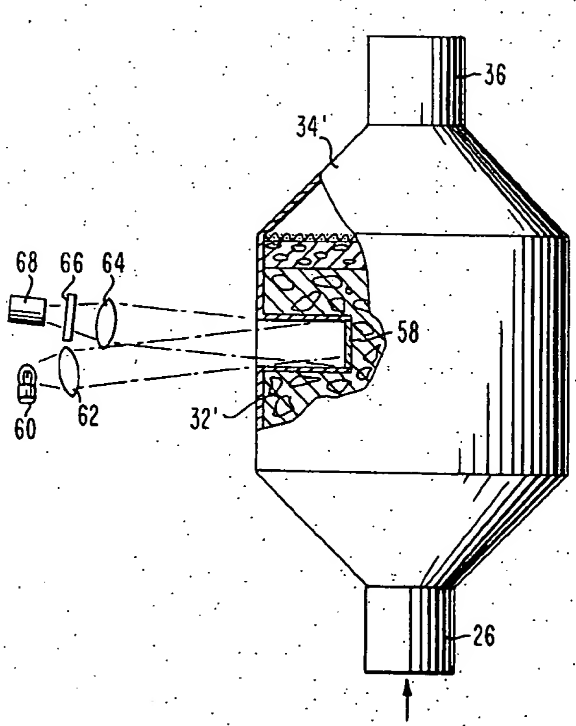


FIG. 5

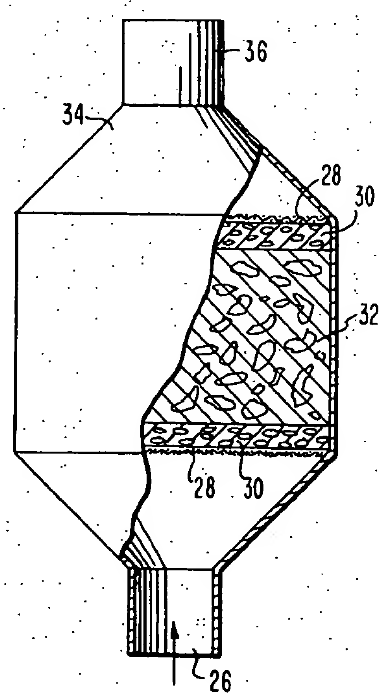


FIG. 3

SYSTEM TO PREVENT THE FORMATION OF PARTICULATE MATERIAL IN CORONA UNITS

BACKGROUND OF THE INVENTION

This invention relates to corona discharge devices and more particularly to a method and apparatus for eliminating certain particulate deposition within corona discharge devices.

Corona discharge devices have been widely used in prior art systems as ion generators for electrostatic charging. These prior art corona discharge devices have had, after a period of usage, a particulate material collect on the insulating surfaces of the corona unit as well as the non-corona electrodes such as screens or a conductive backing electrode. The growth of the particulate material on the screens or backing electrodes increases the arc probability and also changes the charge efficiency of the corona device. At high humidities the wet particulate material further increases the chance of electrical shorts and corrosion of corona components. The particulate material may also contaminate nearby components such as the photoconductor in an electrophotographic imaging system for example. The problem of particulate material deposition within corona discharge devices has been solved in prior art systems by periodic cleaning of the corona devices which may be accompanied by periodic restringing of the corona wires. The mechanism which causes particulate deposition within the corona discharge device is not completely understood, and the deposition varies depending upon whether a positive or negative corona discharge is produced. However, one reason for the prior art practice was because of the belief that all components of the particulate material are totally generated in the normal operation of the corona devices, since it was believed that the corona units generate from the normal gases in air, ozone, oxides of nitrogen, and ammonia which combine to produce the particulate material. In systems utilizing corona devices in which the components of the system are required to have maintenance free operation for a long period of time, the prior art solution is no longer suitable. In investigating alternatives to the prior art practices, it was discovered that the internally generated particulate material comprises but a small percentage of the total particulate material. It was discovered that oxides of nitrogen were generated in relatively large amounts by both positive and negative corona discharges and that these oxides react readily with ammonia to form ammonium nitrate particulate which appears to be the particulate formed with the greatest concentration. However, the quantity of the ammonium nitrate particulate formed could not be attributed to the internal generation of ammonia within the corona since the concentration was much too low for the ammonium nitrate particulates. It was discovered that the formation of particulate materials is greatly affected by the level of ammonia in the ambient air which may be introduced to the corona discharge device.

SUMMARY OF THE INVENTION

It is therefore the principle object of this invention to produce a corona discharge device which is free of the deposition of particulate material and thus capable of producing maintenance free operation for a long period of time.

Briefly, according to the invention, apparatus is provided for supplying a flow of air to a corona discharge device over a path which includes filtering means comprising a chemically active material to react with certain components in the flow of air to prevent the formation of particulate material in the corona device and associated apparatus.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of an electrophotographic apparatus embodying the present invention;

FIG. 2 is a block diagram of the air filtering system embodying the present invention;

FIG. 3 is a view partially in section of the ammonia filter;

FIG. 4 is a cross-sectional view of the charge corona showing the air path through the corona unit;

FIG. 5 is a partial cross-section view of the ammonia filter showing the addition of a use level sensing device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

This invention is applicable in general to corona discharge devices utilized as ion generators for electrostatic charging. However, the embodiment of the invention described relates to an electrophotographic apparatus since the particulate material deposition problem may be particularly severe in this environment. In this electrophotographic apparatus shown in FIG. 1, a rotatable drum 1 carries around its periphery of an electrophotographic photoconductive member upon which is directed an image which it is desired to be produced on continuous form web 6. The surface of the photoconductor is uniformly charged to a predetermined polarity by corona discharge device 2. The charged surface is exposed to a light image at the forms flash station 3 and/or exposure station 4 to produce a latent electrostatic image. The latent electrostatic image is developed by a suitable development unit 5 at which a toner carrier mixture is cascaded across the electrostatic image on the surface of the photoconductor as is known in the art. The toner has a charge such that it is attracted to the drum surface to render the image visible. The toned image is transferred to continuous form sheet 6 with the aid of transfer corona unit 7. The transfer corona unit sprays ions on the backside of sheet 6 of a polarity opposite that of the toner, thereby attracting the toner image from drum 1 to sheet 6. After the corona transfer the paper 6 is separated from the drum and fed past a fusing station 8 which serves to fuse and permanently fix the toner to the paper. Since transfer of all the image toner is not usually accomplished, residual toner usually remains on the drum surface after a transfer operation. At the cleaning station the photoconductor is exposed successively to an erase lamp 9, a pre-clean corona 10 and a rotating cleaning brush 11. The erase lamp discharges the photoconductor and the pre-clean corona produces a charge so that the residual image toner is attracted electrostatically to the cleaning brush which sweeps the toner from the photoconductor surface. This operation completes the cycling of the drum for producing the desired image.

Control means 14 is provided to supply electrical control signals to coordinate the operation of all components of the system. In this manner the position of the image on the drum can be coordinated so that the

proper action takes place at the stations around the drum at the proper time. In addition, control means 14 may also provide temporary storage for image data supplied to exposure station 4 if desired.

According to the present invention, the charge corona 2 has associated therewith a filtering means 15 and an air flow means 16 which produces a flow of air through the charge corona unit to reduce or eliminate three types of contamination within the corona unit, namely, corrosion, deposition of particulate materials and dust. In the embodiment shown, filtering means 15 comprises a particle filter which receives the air from air flow means 16. In the embodiment shown, air flow means 16 comprises a suitable blower. Particle filter 20 is a device suitable for removing particles above about 1 micron in size from the flow of air and this filter is operable to greatly reduce the dust contamination in the charge corona. Air from particle filter 20 is passed to ammonia filter means 22 where any ammonia present in the air reacts chemically to produce virtually ammonia-free and dust-free air for introduction into the charge corona. The air is channeled through the charge corona so that the air flow tends to keep the corona wires clean. In addition, the flow path within the charge corona is set up so that any remaining toner particles near the photoconductor surface are kept away from the wires by the air flow and swept out of the corona unit along with the ozone that is normally generated within the corona unit. This air is directed through a suitable ozone filter 24 to remove the ozone generated within the charge corona unit and the air from the ozone filter can either be exhausted from the system or returned to the system for recycling.

A specific embodiment for ammonia filter 22 is shown in FIG. 3. The air from particle filter 20 enters through port 26, goes through a quantity of chemically active material 32 which is provided in housing 34 and continues to exit port 36. Housing 34 is made from or coated with a material that is chemically inert relative to the chemically active material, and is designed to facilitate the flow of air through the filter. The chemically active material is held in position by a retaining member 28 and a spacer member 30 on either side of the chemically active material. Retaining member 28 comprises any suitable member which will physically constrain the chemically active material and permit the free flow of air through the member. A screen member with greater than 50 percent open area is suitable for the retainer member. Spacer member 30 comprises any suitable chemically inert material such as an open cell foam for example. In a particular embodiment a polyurethane foam having 40 to 80 pores per inch was found to be suitable. The retaininng member 28 and spacer member 30 perform the dual functions of holding the chemically active material in place and uniformly distributing the air flow across the filter.

The chemically active material comprises a suitable carrier material and an active ingredient such as an acid which reacts with certain components in the air. The carrier material should either be porous or have a high surface area and be compatible with an indicator if used. The active ingredient should react readily with the components to be removed from the air, have a low vapor pressure, and be chemically inert relative to the carrier material.

One suitable chemically active material is a carrier material comprising activated charcoal treated with a solution of sulfuric acid. The activated charcoal is soaked in sulfuric acid. The resultant material is then vacuum dried and, since sulfuric acid has a very low vapor pressure, a substantial amount of the sulfuric acid is adsorbed in the pores of filter material. A typical filter treated in this manner contains about 5 percent of sulfuric acid by weight. An alternate chemically active material is a carrier material comprising silica gel treated with a solution of phosphoric acid. The silica gel is soaked in phosphoric acid. The resultant material is vacuum dried and a substantial amount of phosphoric acid is adsorbed in the pores of the carrier material. A typical filter treated in this manner may contain about 15 percent of phosphoric acid by weight. This construction of the ammonia filter provides a large surface area for reacting with the ammonia present in the air to be supplied to the charge corona.

A specific embodiment of the charge corona is shown in FIG. 4. The charge corona comprises a plurality of corona wires 40 spaced apart a predetermined distance and a plurality of screen wires 42 that are spaced apart a considerably shorter distance than the spacing between corona wires. A suitable power source 44 is provided to supply a corona generating potential such as several kilovolts for example to corona wires 40 and a lower potential to screen wires 42. The voltages are referenced to the photoconductor backing electrode which is normally at ground potential. An inner housing 48 is provided which has end members extending close to the surface of the photoconductor to produce a controlled flow of air through the corona device. The portion of housing 48 which extends away from the photoconductor is divided by a perforated plate member 50 so that the part of the housing behind the plate member provides a manifold for the air directed to the charge corona. The air is directed from outlet port 36 to inlet 52 by suitable ducts and is forced through the holes in plate member 50 across the corona wires and screen wires toward the photoconductor surface. An outer housing 56 is provided on the charge corona and an air outlet 54 is provided so that a pressure differential can be established between the input air and the output air to cause a controlled flow of air substantially according to the arrows shown in the drawing. The result of the illustrated air flow is that all contaminating dust is carried away from the corona and screen wires and out through outlet 54. In addition, the ozone that is generated within the charge corona is also carried away through this outlet.

Some additional air is pulled into the charge corona around the gap between outer housing 56 and the photoconductor surface to insure that the flow of air along with the dust and ozone contaminants are removed from the charge corona rather than being distributed to other parts of the machine due to escape from housing 56.

With the above described apparatus the ammonia level in the air introduced to the charge corona is less than one part per billion and this is effective in eliminating the particulate deposition problem so that the charge corona can be operated for long periods of maintenance free operation.

The ammonia level in air varies considerably. In unpolluted air the average is about 6 parts per billion; however, the air near chemical processes which produce or use ammonia have much higher amm nia levels, perhaps as high as 5000 parts per billion. The

amount of the chemically active material in the filter determines the ammonia capacity of the filter. Since the ammonia level in air is variable, the life of the filter is also variable. In a system in which long intervals of maintenance-free operation are desired, a filter end-of-life indicator is desirable. An end-of-life indicator is provided in the embodiment shown in FIG. 5. The indicator operates on the basis of the change in the pH of the system as the chemically active material goes, for example, from phosphoric acid to ammonium phosphate. The chemically active material is made from a suitable carrier material to which a suitable color indicator can be added to show when the pH of the system gets to the critical value. In the embodiment shown, a window **58** is provided in a recess within housing **34'** which is transparent to the spectrum of the light from light source **60**. Light source **60** is imaged on the window **58** by a suitable lens **62** and the light transmitted back through window **58** is collected by lens **64** and passed through a suitable color filter **66** to a photocell **68**. As a specific example, the carrier material is silica gel which has been treated as described above with phosphoric acid. A suitable color indicator material such as crystal violet is also introduced into the chemically active material **32'**. The material is normally light yellow; however, at the critical pH designated to indicate end-of-life of the filter, the color indicator material changes to dark violet so that the amount of light reaching photocell **68** changes and a suitable electrical signal can be generated by monitoring the photocell output signal. The signal generated from the photocell is used as a signal to the machine operator that the filter has reached the end of life. Since the filter is normally used up rather slowly, the indication could be set at some value less than 100 percent usage of the chemically active material so that some amount of operating time would be left after the signal is generated so that the filter could be changed at a convenient time in the operation of the machine.

The color change starts at the input side of the filter and progresses toward the output side. The vertical position of window **58** along the filter can be chosen at any particular position so that the indication corresponds to the desired usage level. An elongated transparent window may be mounted vertically in housing **34'** to provide a visual indication of the usage level of the filter. It is obvious that a light transmission system can be utilized for the filter end-of-life indicator wherein a color change or a density change can be sensed.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for producing charge on a surface comprising; comprising:
   corona means for producing a charge on a surface;
   means for producing a flow of air having undesired gaseous components therein to and through said corona means over a predetermined path;
   filtering means positioned in said predetetermined path between said means for producing a flow of air and said corona means so that said air flows through said filtering means, said filtering means comprising a carrier material treated with an acid to form a chemically active material to produce a chemical reaction with certain of said undesired gaseous components in said flow of air to prevent the formation of particulate material in said corona means over an extended period of operation.

2. The apparatus according to claim 1 wherein one of said undesired gaseous components in said flow of air is ammonia and wherein said chemically active material produces a chemical reaction with the ammonia in said flow of air.

3. The apparatus according to claim 1 wherein said chemically active material comprises activated charcoal which is treated with sulfuric acid.

4. The apparatus according to claim 1 wherein said chemically active material comprises silica gel which is treated with phosphoric acid.

5. The apparatus according to claim 1 wherein said chemically active material comprises silica gel which is treated with phosphoric acid.

6. An electrophotographic apparatus for producing an image on a recording surface comprising:
   corona means for producing a charge on a recording surface;
   means for producing a flow of air having undesired gaseous components therein to and through said corona means over a predetermined path;
   filtering means positioned in said predetermined path between said means for producing a flow of air and said corona means so that said air flows through said filtering means, said filtering means comprising a carrier material treated with an acid to form a chemically active material to produce a chemical reaction with certain of said undesired gaseous components in said flow of air to prevent the formation of particulate material in said electrophotographic apparatus over an extended period of operation.

7. The apparatus according to claim 6 wherein said chemically active material comprises activated charcoal which is treated with sulfuric acid.

8. The apparatus according to claim 6 wherein one of said undesired gaseous components in said flow of air is ammonia and wherein said chemically active material produces a chemical reaction with the ammonia in said flow of air.

9. The apparatus according to claim 6 additionally comprising means to sense when said filtering means reaches end-of-life.

10. The apparatus according to claim 9 wherein said sensing means comprises means for sensing a color change when said filtering means reaches end-of-life.

11. The apparatus according to claim 9 wherein said sensing means comprises means to sense when said chemically active material reaches a predetermined concentration.

12. The apparatus according to claim 11 wherein said means to sense when said chemically active material reaches a predetermined concentration comprises an indicator material within said filtering means which changes color at said predetermined concentration and means to sense the color change.

13. The apparatus according to claim 12 wherein said indicator material comprises crystal violet.

14. The apparatus according to claim 12 wherein said chemically active material c mprises silica gel which is

treated with phosphoric acid and wherein said indicator material comprises crystal violet.

15. The apparatus according to claim **12** wherein said chemically active material comprises silica gel which is soaked in phosphoric acid and then vacuum dried and wherein said indicator material comprises crystal violet.

* * * * *

US006168689B1

(12) United States Patent
Park et al.

(10) **Patent No.:** **US 6,168,689 B1**
(45) **Date of Patent:** **Jan. 2, 2001**

(54) **METHOD AND APPARATUS FOR CLEANING EXHAUST GAS DISCHARGED FROM INTERNAL OR EXTERNAL COMBUSTION ENGINE BY USING HIGH VOLTAGE ELECTRIC FIELD**

(75) Inventors: **Chan-Ho Park**, Seoul; **Yong-Hee Lee**, Kyungki-do, both of (KR)

(73) Assignee: **Seondo Electric Co., Ltd.**, Kyungki-do (KR)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/105,649**

(22) Filed: **Jun. 26, 1998**

Related U.S. Application Data

(63) Continuation-in-part of application No. PCT/KR96/00007, filed on Jan. 19, 1996.

(30) **Foreign Application Priority Data**

Dec. 28, 1995 (KR) 95-61243

(51) **Int. Cl.**[7] **B01J 19/08**

(52) **U.S. Cl.** **204/164**; 204/177; 422/186.04; 422/186.3; 588/227

(58) **Field of Search** 204/164, 177; 422/186.04, 186.3; 588/227

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Primary Examiner—Kishor Mayekar
(74) *Attorney, Agent, or Firm*—Dilworth & Barrese

(57) **ABSTRACT**

A method and an apparatus for cleaning smoke and reducing noises of an internal combustion engine or external combustion engine by using a high voltage field. The present invention relates to a method and an apparatus which can clean exhaust gases and reduce noise, wherein it comprises the step of burning up the granular particles with corona discharge after changing particles into plasma state, the step of removing gaseous materials with negative ions, the step of eliminating NOx with ultraviolet rays and the step of reducing noise.

31 Claims, 16 Drawing Sheets

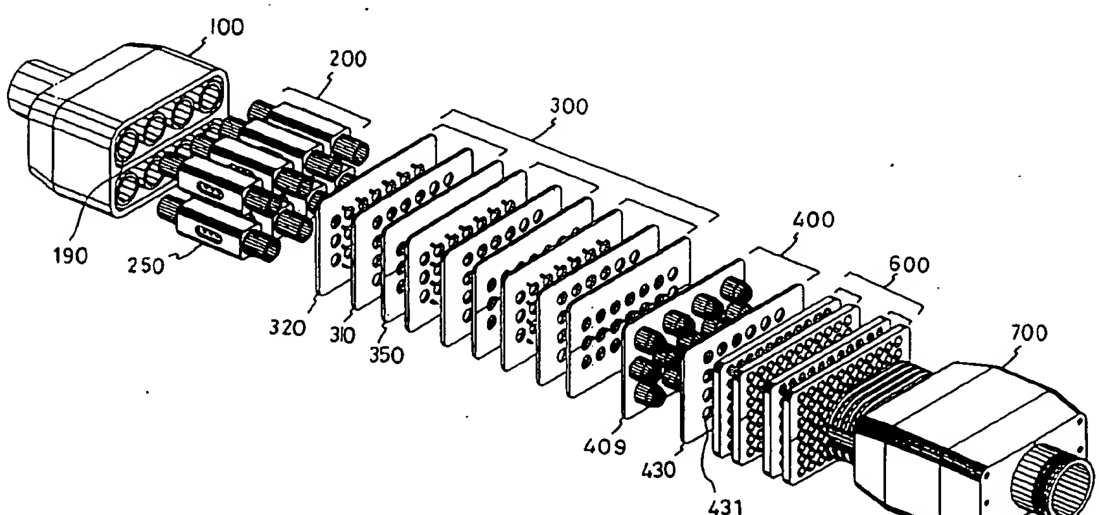


Fig. 1

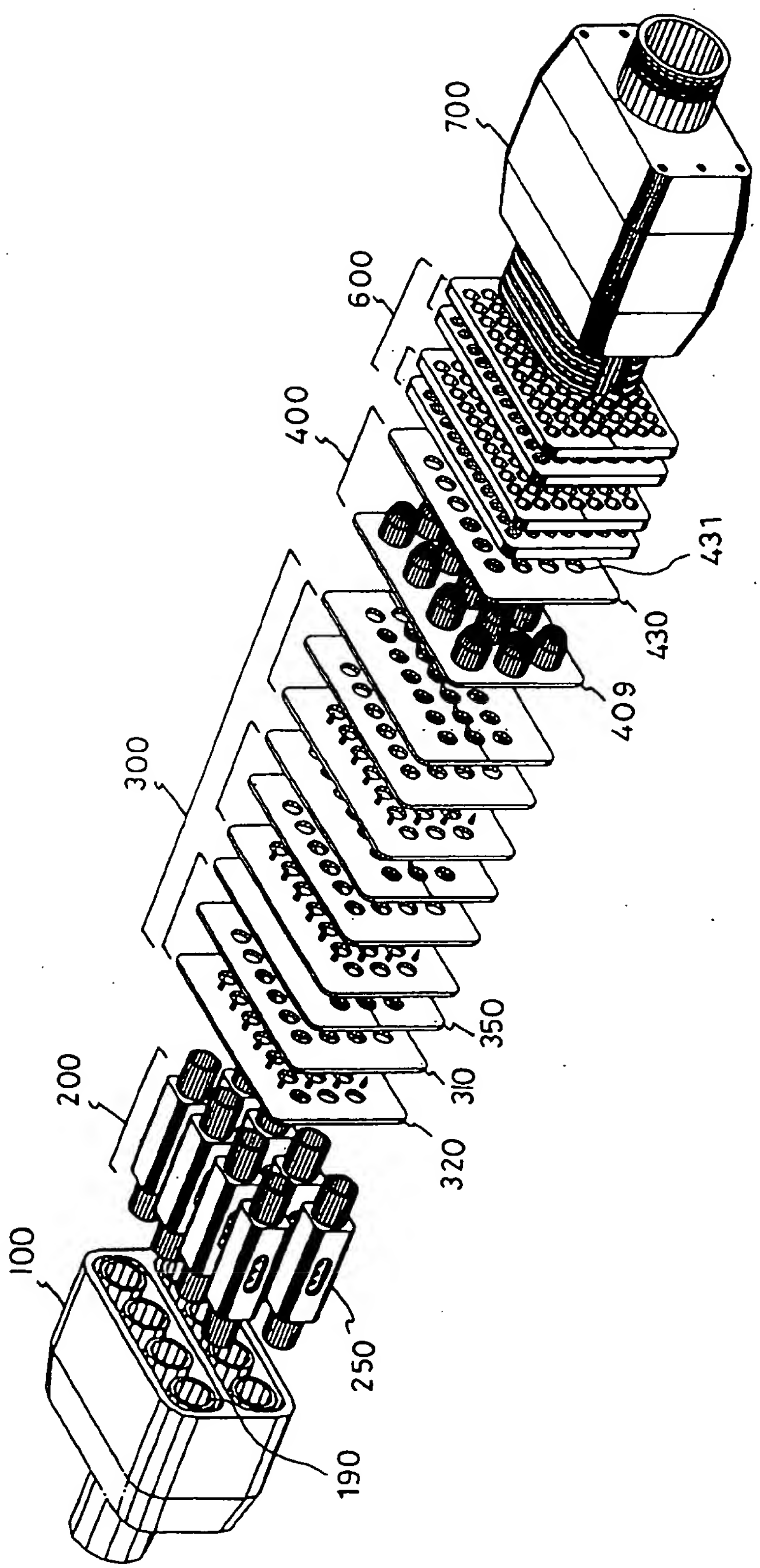


Fig. 2(a)

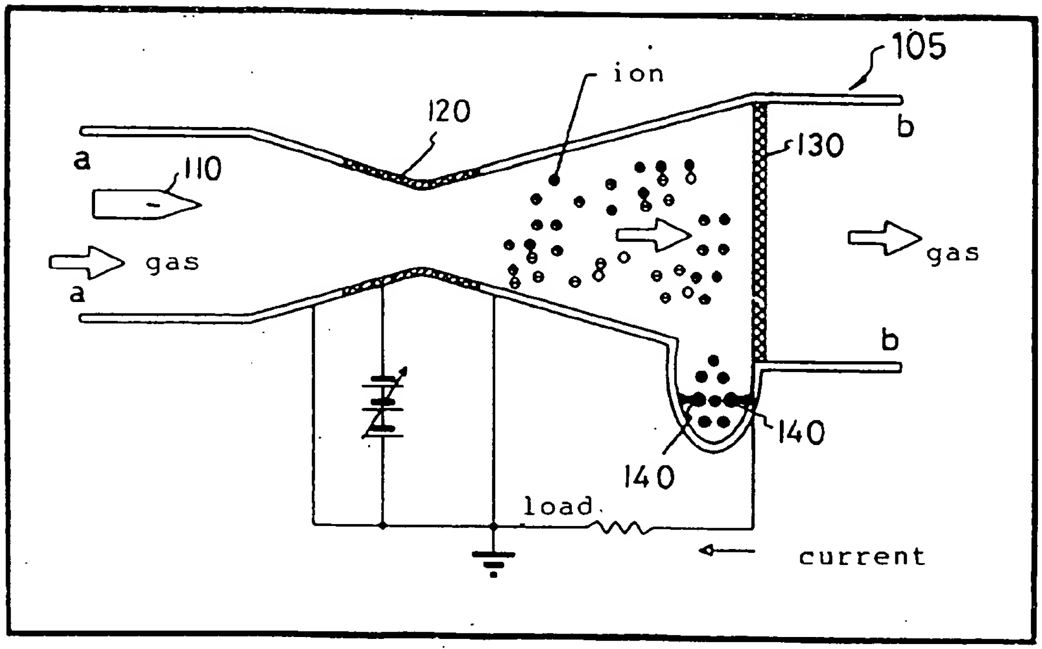
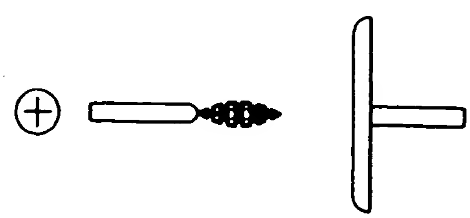


Fig. 2(b)



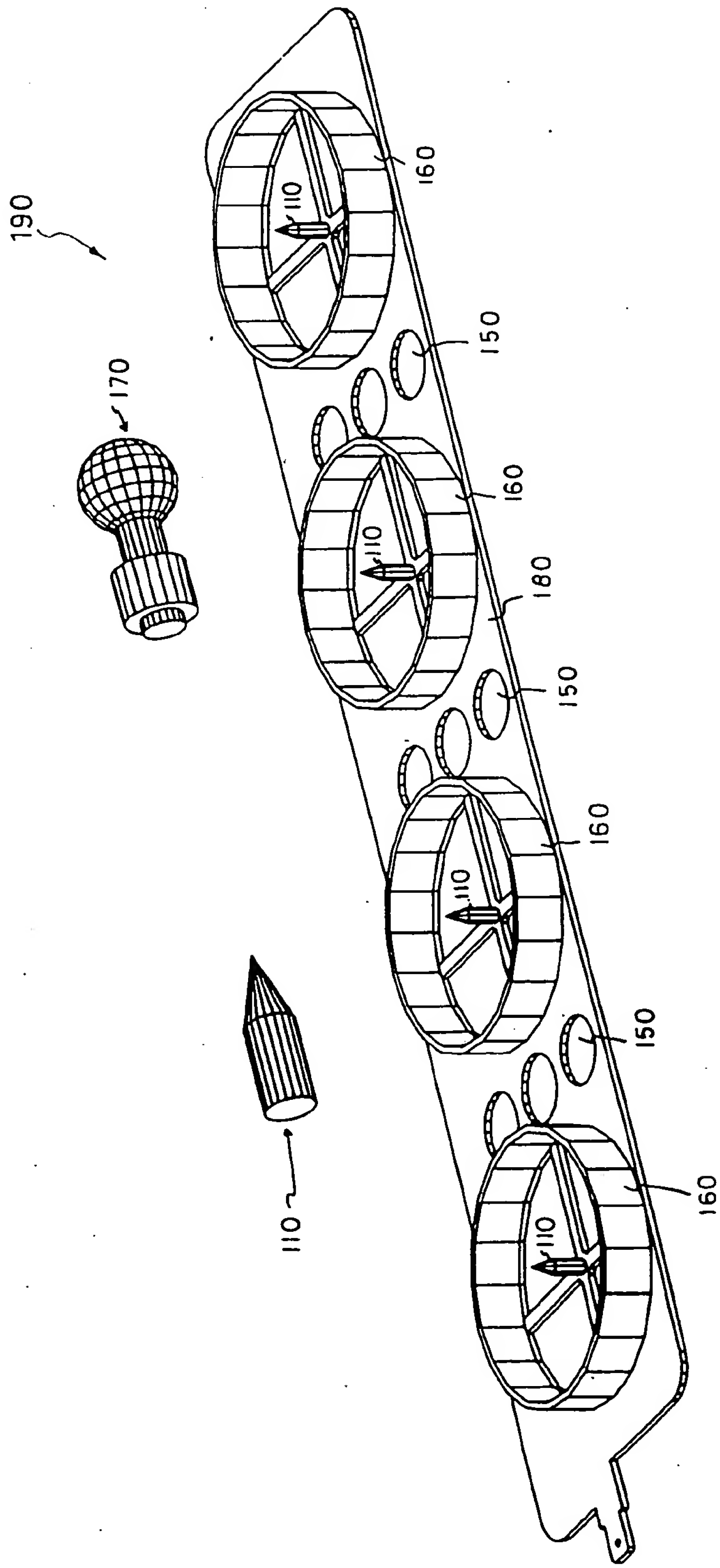


Fig. 3(a)

Fig. 3(b)

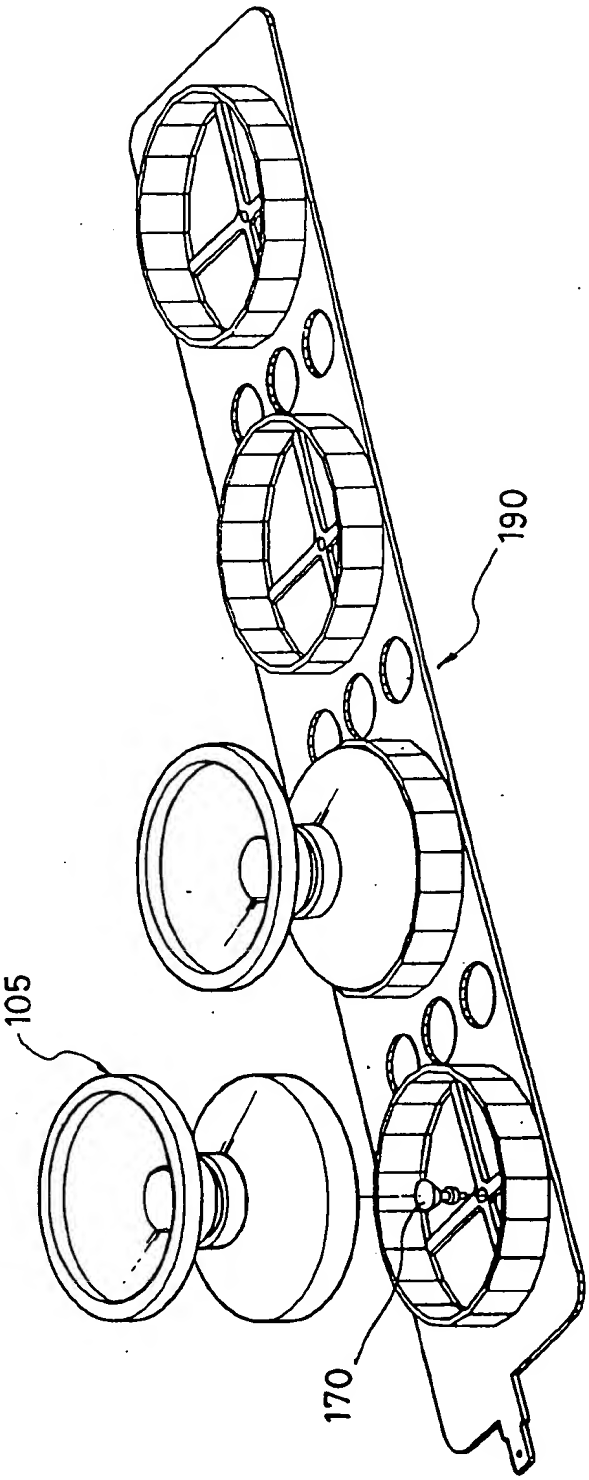


Fig. 4(a)

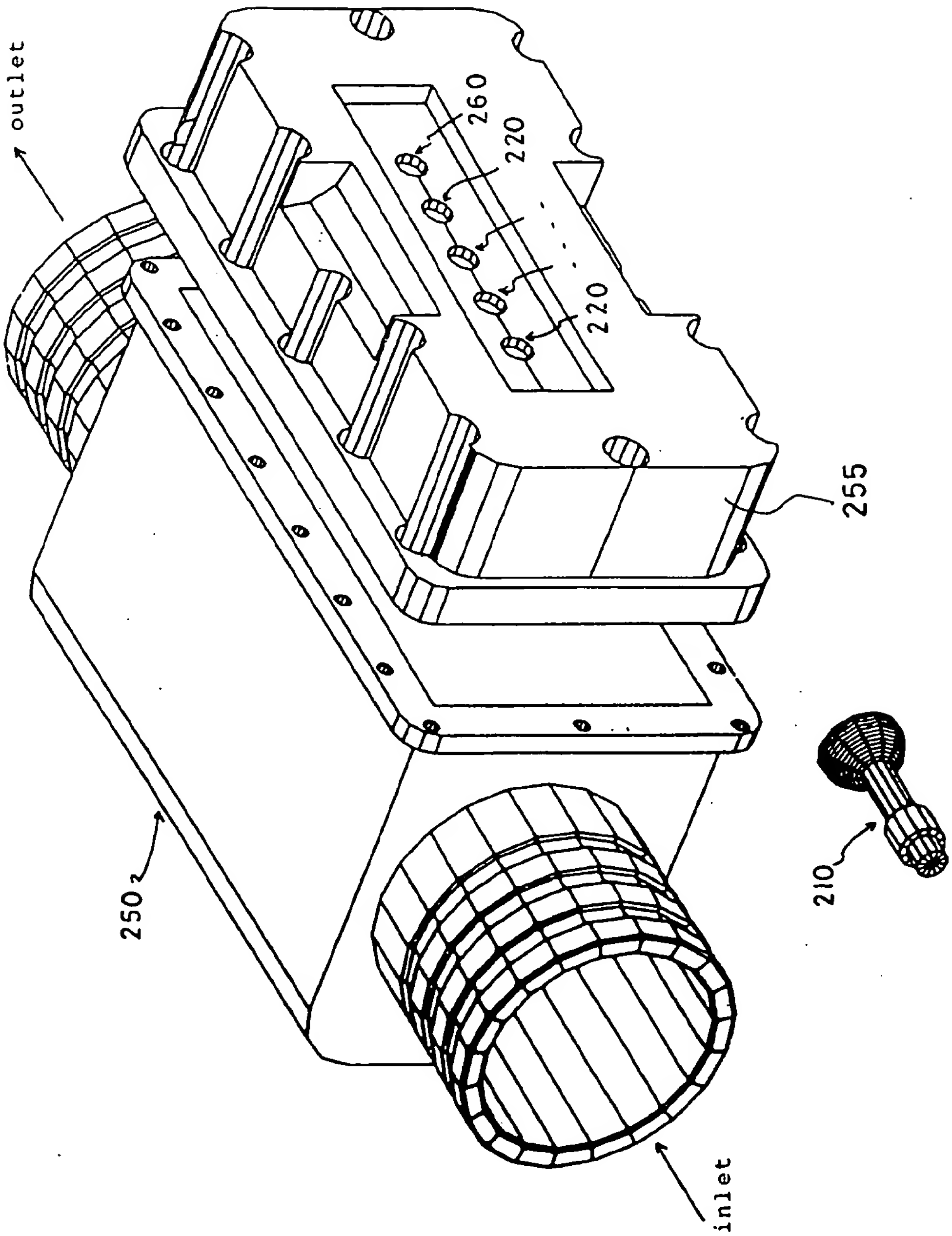


Fig. 4(b)

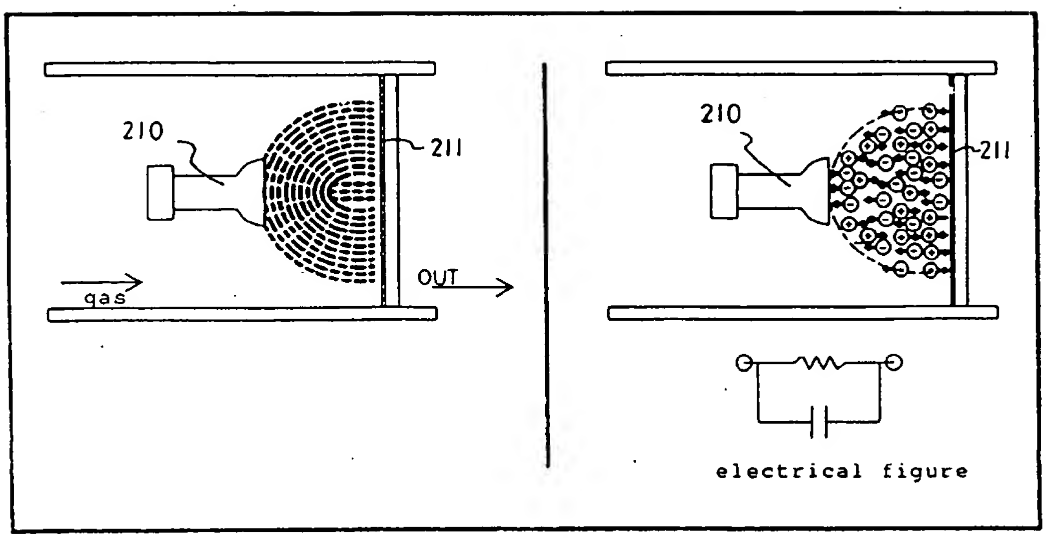
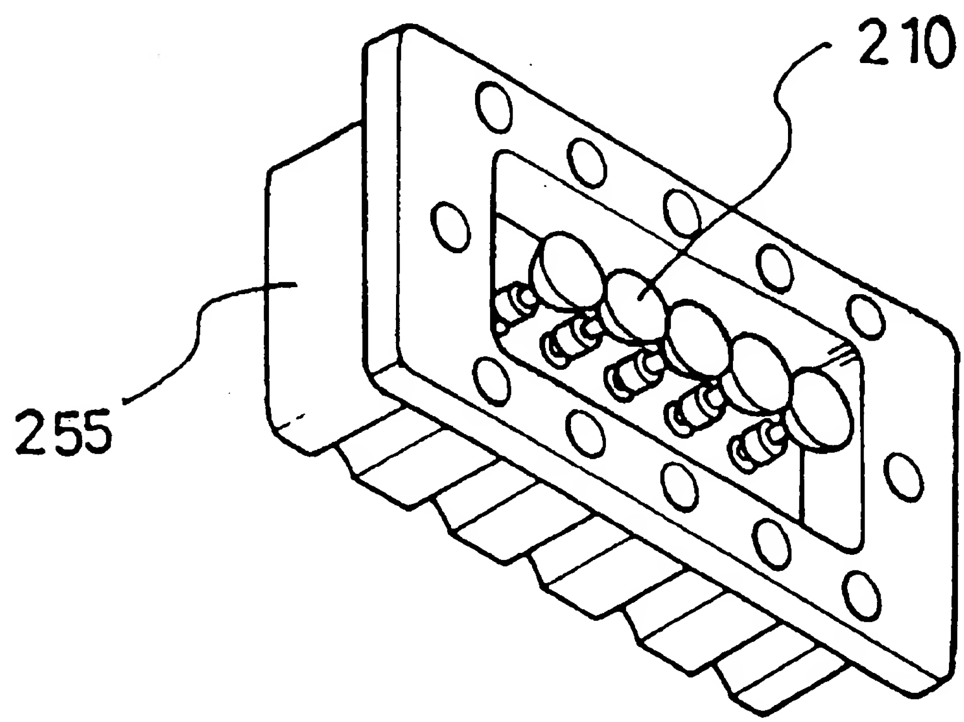


Fig. 4(c)



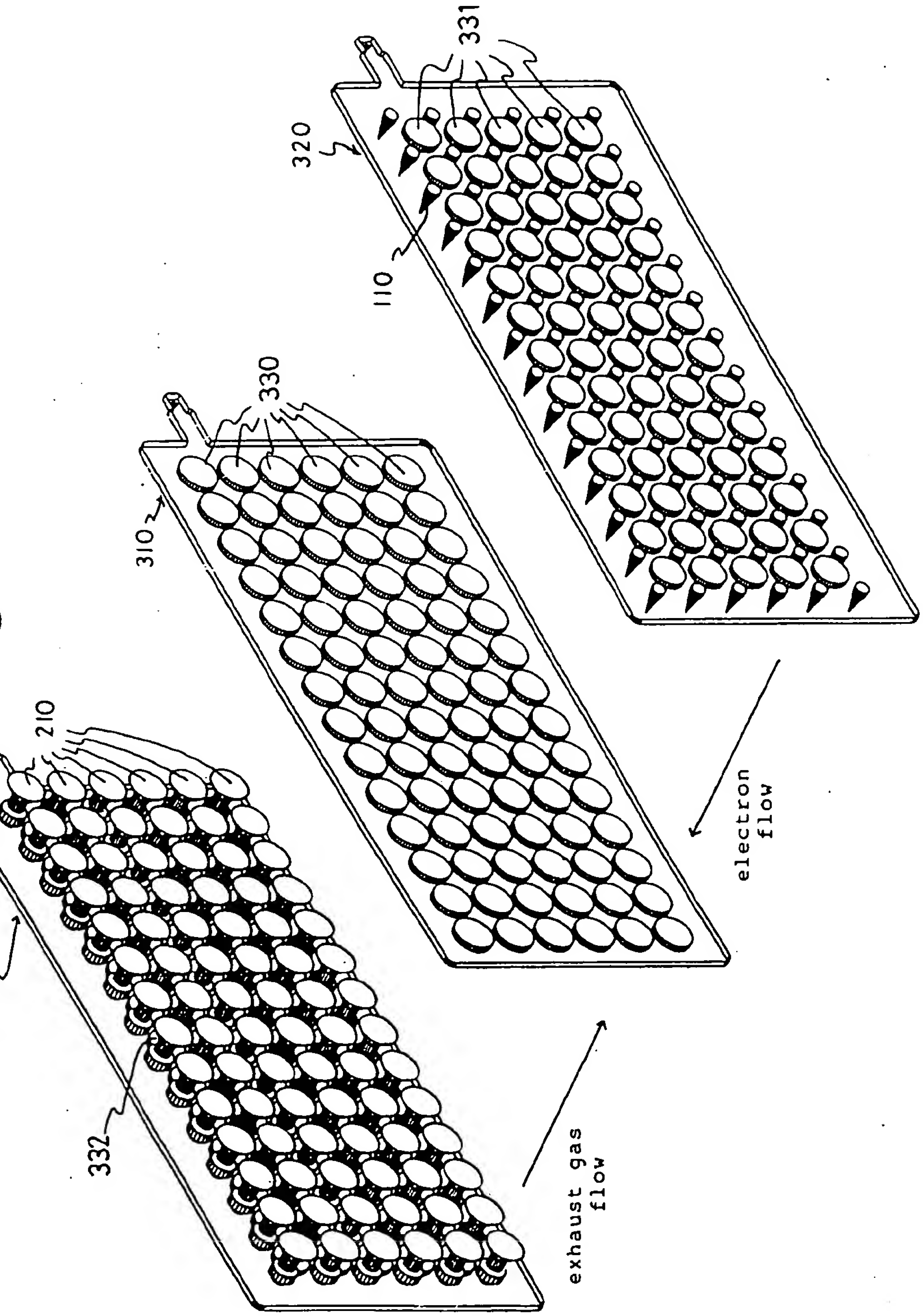

331
320
110
330
310
210
350
332
electron flow
exhaust gas flow

Fig. 5(a)

Fig. 5(b)

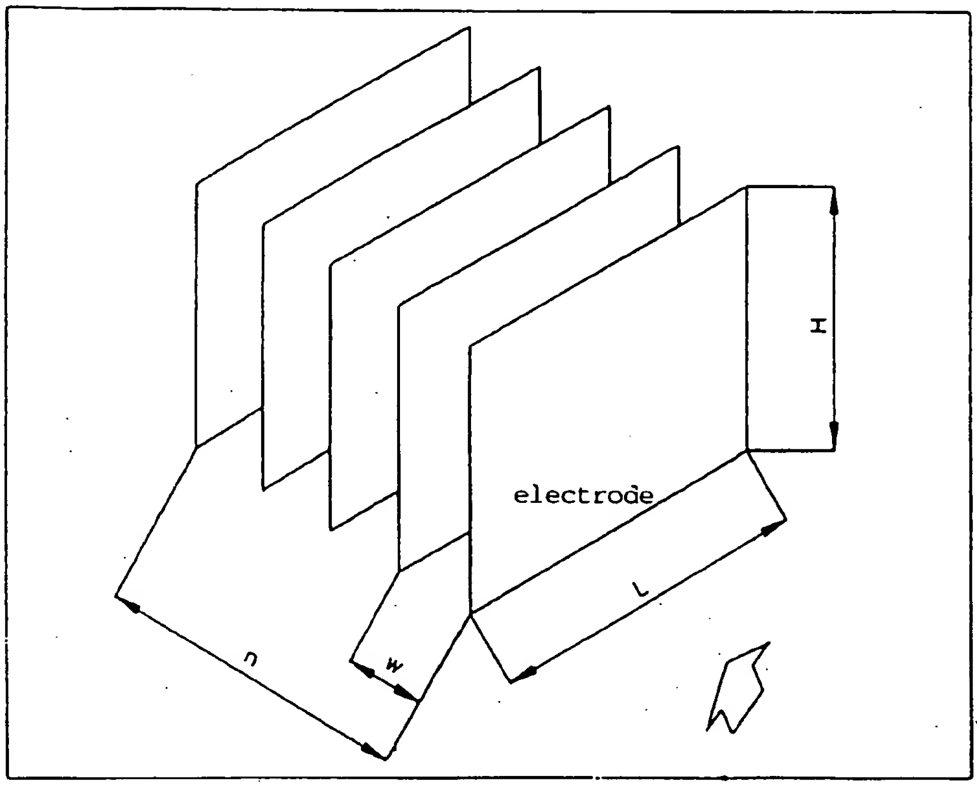


Fig. 5(c)

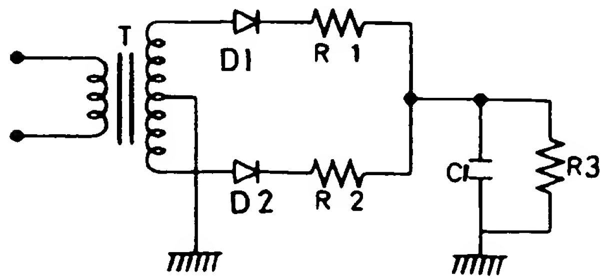


Fig. 5(d)

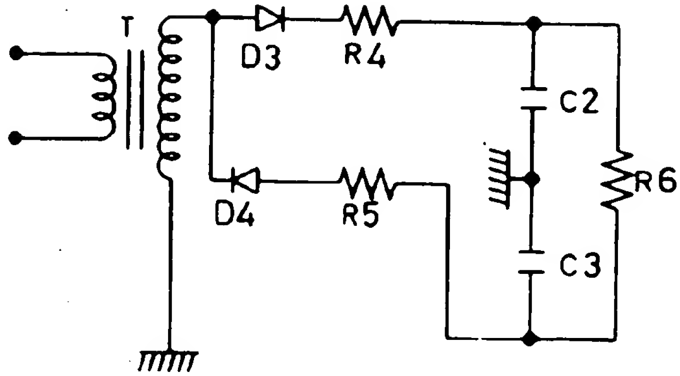
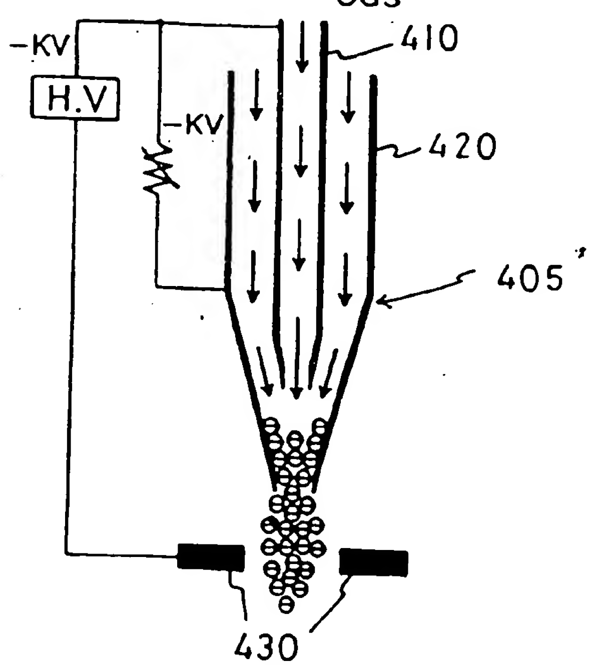


Fig. 6



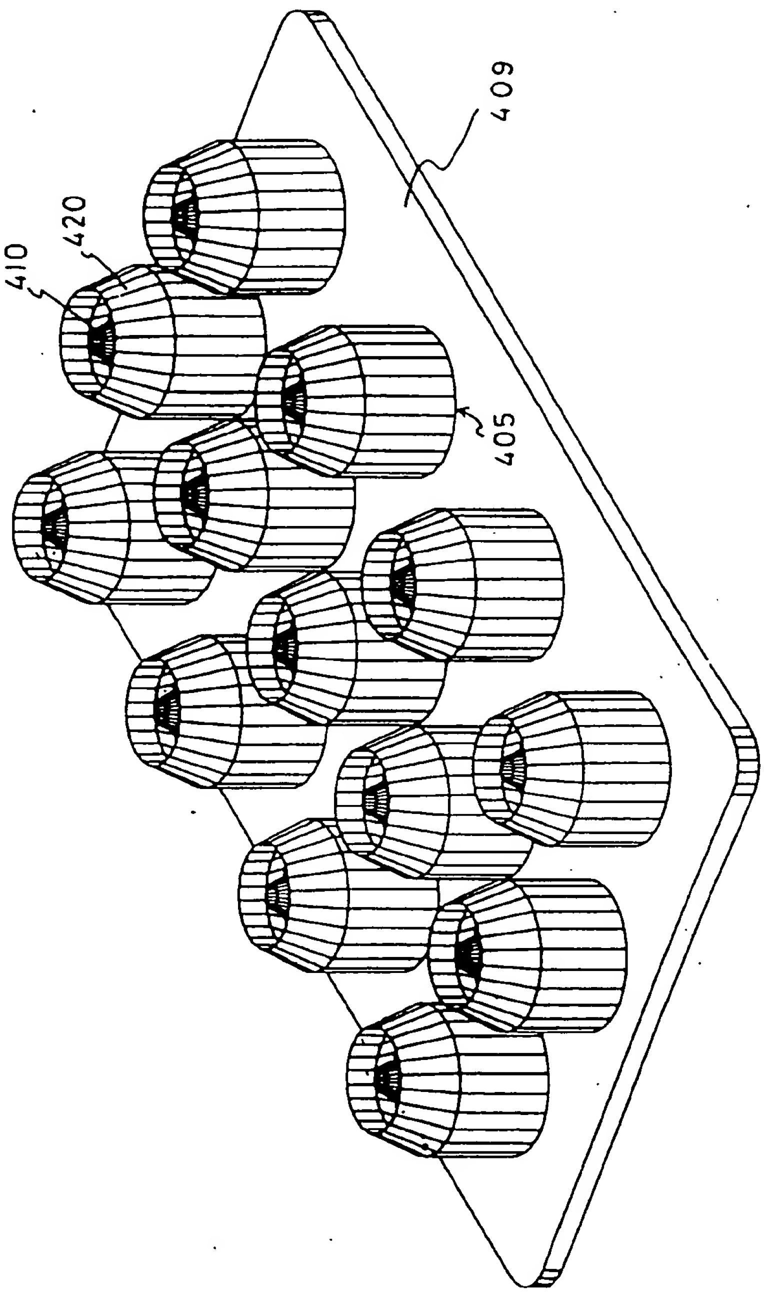


Fig. 7

Fig. 8

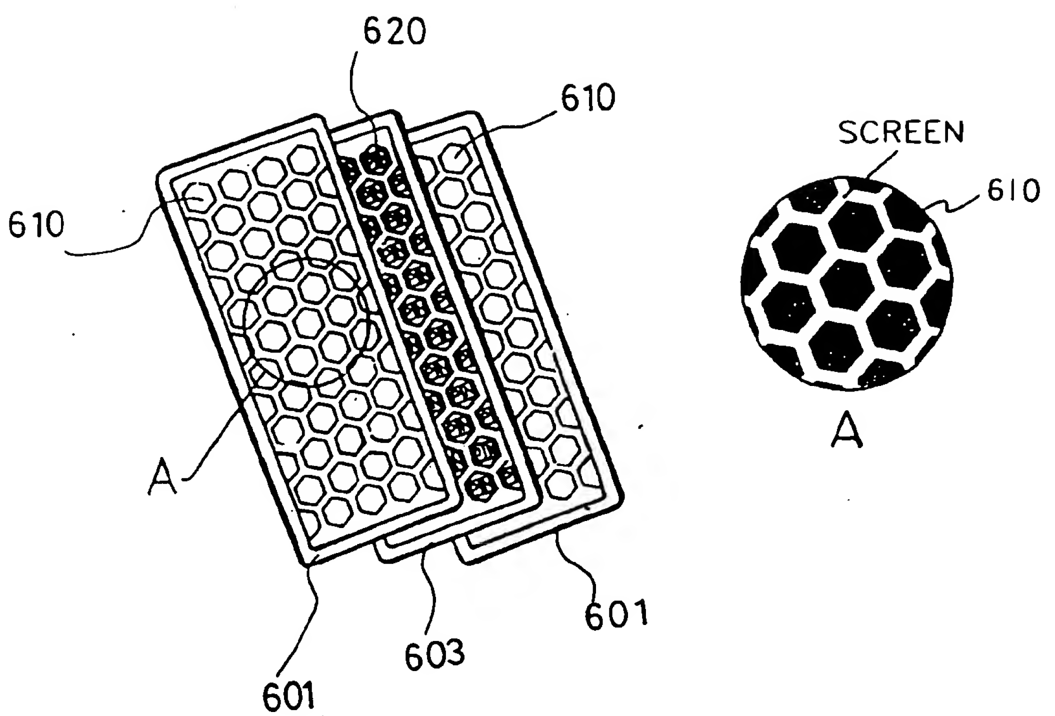


Fig. 9(a)

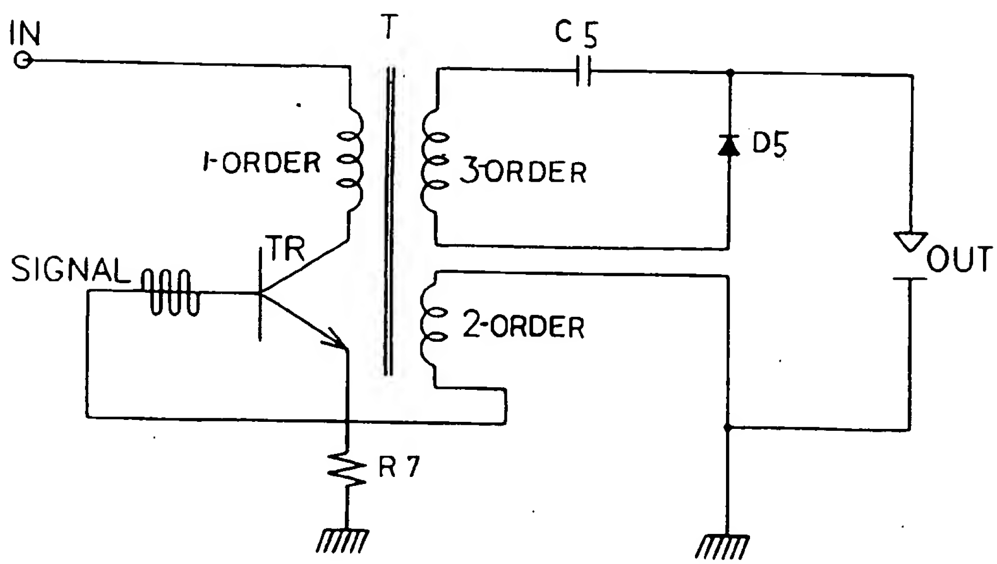


Fig. 9(b)

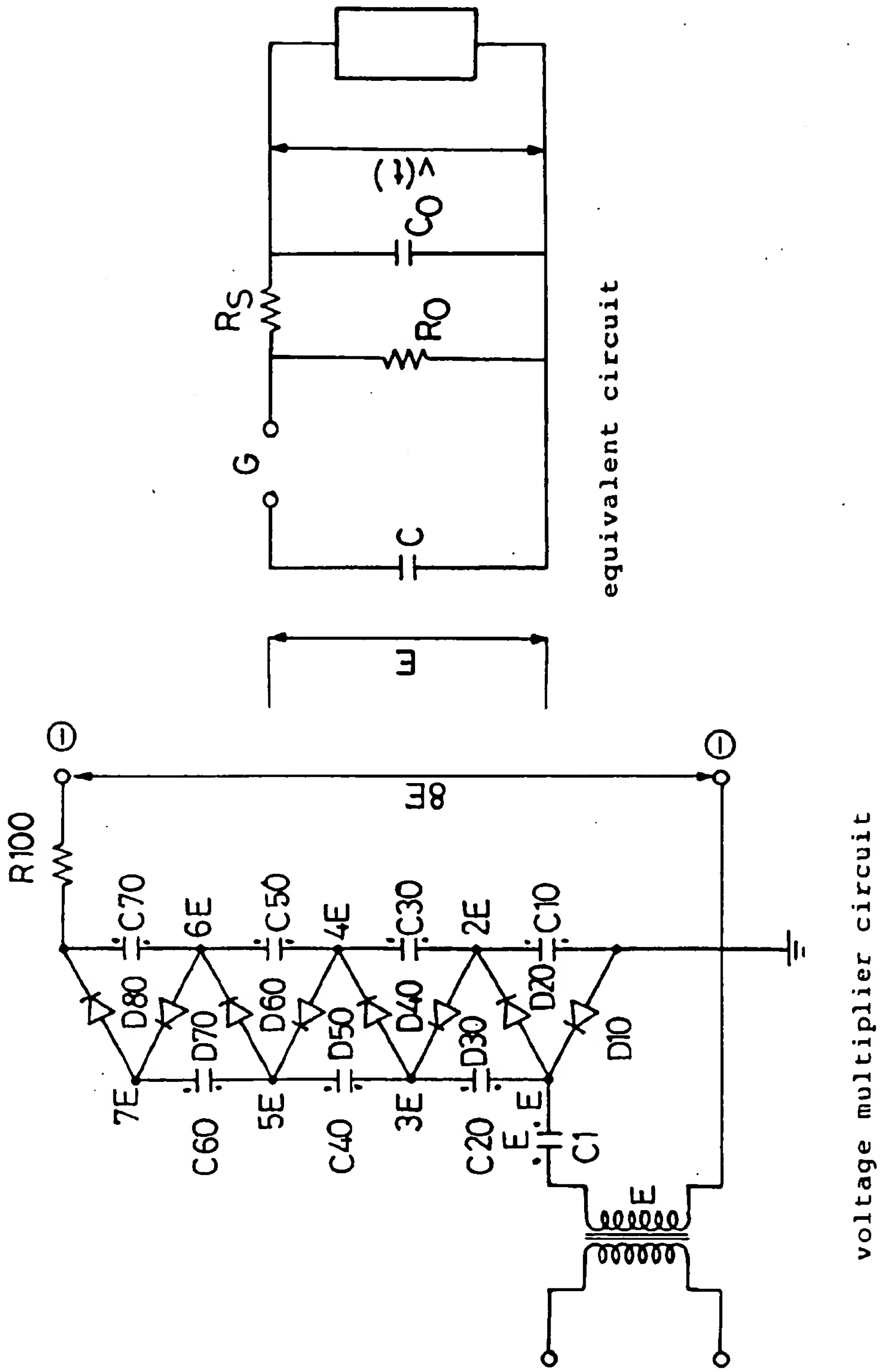
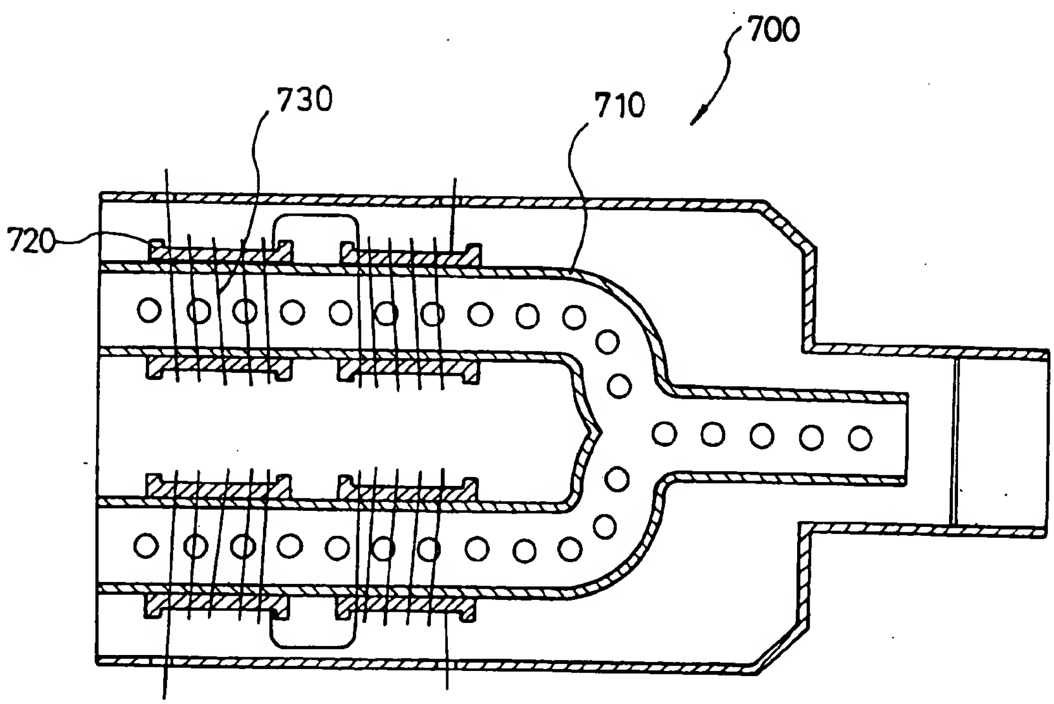

equivalent circuit
G
C
E
R_S
R_O
C_O
v(t)
voltage multiplier circuit
R100
8E
C70
6E
C50
4E
C30
2E
C10
D80
D70
D60
D50
D40
D30
D20
D10
7E
5E
3E
E
C60
C40
C20
C1

Fig. 10



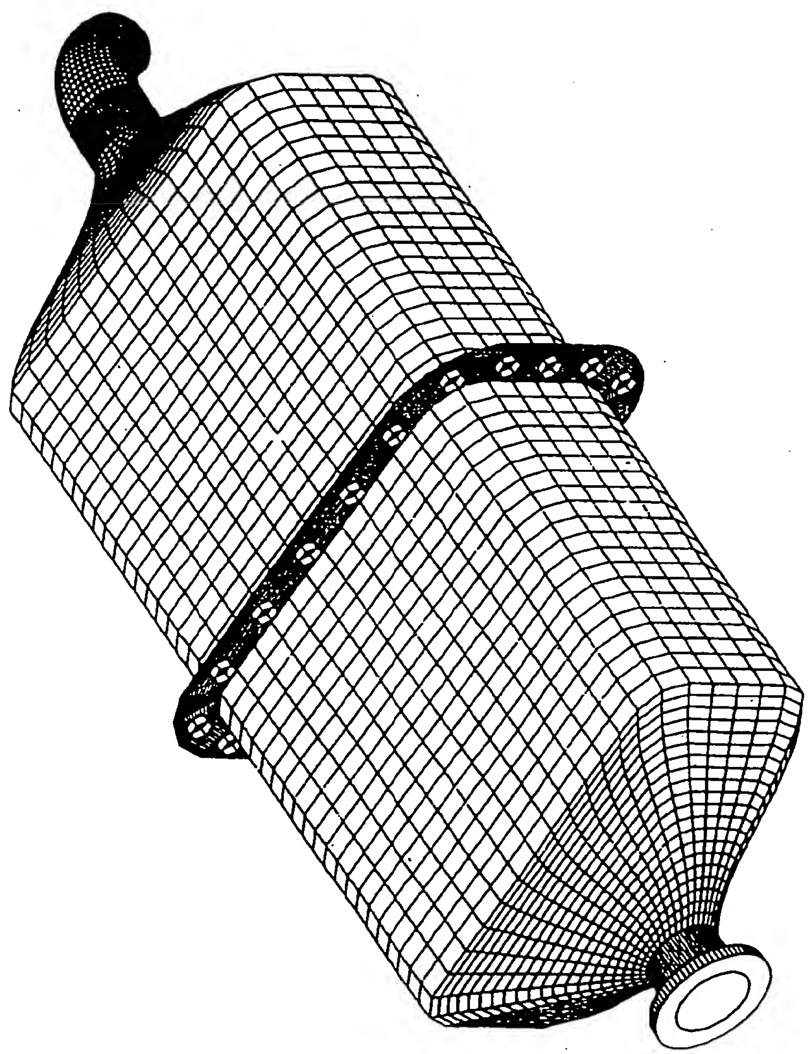


Fig. 11

METHOD AND APPARATUS FOR CLEANING EXHAUST GAS DISCHARGED FROM INTERNAL OR EXTERNAL COMBUSTION ENGINE BY USING HIGH VOLTAGE ELECTRIC FIELD

This is a continuation-in-part of copending International application No. PCT KR96/00007 filed Jan. 19, 1996.

TECHNICAL FIELD

The present invention relates to a method and an apparatus to clean exhaust gas conveying through the chamber, by burning up granular particles under plasma atmosphere, by removing chemical gaseous materials with negative ions, and by eliminating NOx with ultraviolet rays,

which are induced by high voltage electric field. Specifically, the present invention relates to a method and an apparatus which can clean exhaust gas and reduce noise, wherein the method comprises the step of burning up the granular particles with corona discharge after changing particles into plasma state, the step of eliminating NOx with ultraviolet rays, and the step of reducing noise.

The main cause of circumstance pollution are smoke and noise produced by industrial equipments and automobiles. Especially, diesel engines are popularly used, by virtue of their high power and low cost. By the way, in the event of using diesel engines, there occur some problems because diesel engines push out smoke including granular particles, hydrocarbons, NOx, noise and so on, which must be solved to prevent the circumstantial pollution. In order to solve these problems, intensive studies have been carried out about cleaning exhaust gas and reducing noise.

BACKGROUND OF ART

Heretofore known methods make use of catalytic filters, electric field and recombustion of exhaust gas.

In DE 3834920, the system has been described, wherein it burns up the deposited carbon particles in ceramic filter with ozone produced by electric field of 20 KHz and 20 MV.

In WO 9200442, method and device have been described, wherein exhaust gases are taken into a channel of ceramic body where an electric field is generated across the direction of flow, and the soot particles deposited on the walls of the channel are first negatively charged by a discharge electrode and then oxidized by ions adhering to oxygen.

In DE 3711312, the method and apparatus have been described, wherein particles are removed by being ionized with UV rays and by being collected to the plate.

In DE 3314168, the system have been described, wherein neutral particles are divided into two side streams which are directed over electrodes of large surface area, held at opposite potentials.

In U.S. Pat. No. 5,074,112, an apparatus has been described, wherein a filter disposed within the cavity removes particulate products of combustion from exhaust gases passing the cavity and electromagnetic waves produce heat for incinerating particulate products of combustion.

As described above, conventional methods can be applied to eliminate only a kind of soot particle, and so the other ingredients including NOx and noise are pushed out without eliminating.

Accordingly, the inventors of the present invention invented a method and apparatus for cleaning exhaust gas as well as reducing engine noise.

SUMMARY OF THE INVENTION

An object of this invention is to provide a method and an apparatus for cleaning exhaust gas pushed out from engines or industrial equipments and reduce engine noise.

Specially, the object of the present invention is to provide method and apparatus which can clean exhaust gas and reduce engine noise, by partitioning the granular particles and noxious materials in exhaust gas, and then by burning up directly the granular particles under plasma atmosphere, by burning up again the minute particles by means of DC high voltage and AC high voltage, by removing noxious materials with negative ions, by removing NOx by oxidizing it into NO_3 with ultraviolet rays and ozone, which can be easily dissolved in water which is produced by Sellen's effect of PN diode in this apparatus, and by cutting off engine noise and electromagnetic interference.

The apparatus in the present invention is divided into seven units in order to enhance productivity and efficiency of after-service, which can be used in combination or in separately according to the kind of exhaust gas since it has an exhaust gas reducing effect in each unit.

In this invention, a partition unit renders exhaust gas to pass through at high speed and burns up particles which have been collected the partition unit.

In the partition unit, to pass exhaust gas at high speed, EHD(electro-hydro dynamics) method and electrostatic method are applied at a bottle necked nozzle to accelerate the flow of exhaust gas.

The negatively charged particles accelerate much more by voltage difference between an ion pin and attractor electrode, and therefore staying or slowing down of exhaust gas in a chamber is prevented.

The negatively charged particles are attracted by electrostatic force on the collector electrode which is made of a metal mesh and particles which can not pass through the collector electrode of a metal mesh drop down into the manhole where one set of discharge poles is disposed to burn up large particles.

In plasma unit, particles passed through collector electrode are burned by using corona process, wherein small particles are burned by streamer corona generated between a plasma unit pole and mesh. In order to clean exhaust gas more efficiently, exhaust gas is conveyed to electron unit after passing through the plasma unit. Electron unit burns up minute particles by means of DC high voltage and AC high voltage. AC high voltage is applied across a pole plate and hole plate in order to generate streamer corona to burn up minute particles.

DC high voltage is applied across the hole plate and ion pin which pushes particles to the hole plate in order to enhance the efficiency of corona discharge between the hole plate and pole plate.

By the above-mentioned process, granular ingredients of exhaust gas are nearly cleared.

Also, there are noxious chemical materials including NOx in exhaust gas, which are removed with negative ions generated by ionization unit which generates UV rays between plasma jet and opposite electrode, and this UV rays generate a great deal of negative ions. Noxious materials combine with negative ions and ozones to be changed into other materials.

In order to remove NOx which is not removed in the above-mentioned ionization unit, a screen unit is used.

The screen unit comprises a first ceramic plate, and second ceramic plate having hexagonal holes in which PN diodes are disposed.

By action of 10K voltage applied across the plates, UV rays are generated around hexagonal hole in a large amount, and these UV rays let O_2 to be changed into ozone. In addition, PN diodes cause temperature dropping by Sellen's effect to condense gaseous H_2O into water. During above process, the efficiency of removing NOx will be enhanced by taking air into plates.

This invention can contain a union unit, which absorbs engine noise and shields electromagnetic wave to be radiated by high frequency. Union unit is used to meet the regulations of EMI, EMC specification of this inventive apparatus.

According to the above, this invention can clear exhaust gas and can be substituted for a noise absorber.

BRIEF DESCRIPTION OF THE DRAWINGS

This object, and other objects and advantages of the present invention, will appear more clearly from the following specification in conjunction with accompanying schematic drawing, in which:

FIG. 1 is an exploded view of entire components of the inventive apparutus;

FIG. 2(*a*) is a schematic view showing the principle of cleaning exhaust gas in a partition unit;

FIG. 2(*b*) illustrates a discharging type of a brush corona;

FIG. 3(*a*) is an assembling embodiment of a partition unit components;

FIG. 3(*b*) is a perspective view of a nozzle mounted on a partition unit guide assembly;

FIG. 4(*a*) illustrates a discharging view of a plasma unit cell;

FIG. 4(*b*) illustrates a discharging type of streamer corona in a plasma unit cell;

FIG. 4(*c*) is a perspective view of a plasma unit pole mounted in the inner space of a connecting cap of a plasma unit cell;

FIG. 5(*a*) is an exploded perspective view of an electron unit;

FIG. 5(*b*) is a schematic view to calculate the distance between high voltage electrodes at soot clean-up space;

FIG. 5(*c*) and FIG. 5(*d*) schematically illustrate a circuit to supply DC high voltage to an ion pin;

FIG. 6 is a schematic cross-sectional view of an ionization cell illustrating a generating type of plasma jet;

FIG. 7 is a perspective view of a plurality of ionization cells mounted on a cell-plate;

FIG. 8 is a detailed view showing one of the assembling type of a screen unit;

FIG. 9(*a*) is a circuit of high-frequency high voltage generator;

FIG. 9(*b*) is a voltage multiplier circuit to multiply voltage applied across a third order cell;

FIG. 10 is a horizontal sectional view of a union unit; and

FIG. 11 is an external perspective view of the whole apparutus according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, the present invention will be explained in detail referring to the drawings.

Referring to FIG. 1, which shows the entire components of the apparatus for cleaning exhaust gas according to the present invention, the apparatus comprises a partition unit (**100**) which renders exhaust gas to pass through at high speed and burns up large particles which have been collected in a partition unit(**100**), a plasma unit (**200**) which burns up directly granular particles by transforming them into plasma state with streamer corona, electron unit(**300**) which burns up minute particles by means of DC high voltage and AC high voltage, an ionization unit(**400**) which eliminates the noxious materials by generating a great deal of negative ions, a screen unit(**600**) which remove NOx by generating ozone with ultraviolet rays and ions in order to oxidize NOx into NO_3, which can be easily dissolved in water which is produced by Sellen's effect of PN diode(**620**) in screen unit(**400**), a union unit(**700**) which reduces engine noise and shields electromagnetic waves irradiated from the above-mentioned units (**100**, **200**, **300**, **400**, **600**), and high-frequency high voltage generator (not drawn) to supply high voltage to each unit.

Each unit will be explained in detail in the following.

A partition unit(**100**) is shown in detail in FIG. 2(*a*) and (*b*) and FIG. 3(*a*) and (*b*).

Referring to FIG. 2(*a*), illustrating working principle of a bottle-necked nozzle(**105**) in a partition unit(**100**) used to eliminate granular particles by means of slowing down the flow of exhaust gas, the partition unit(**100**) comprises ion pin(**110**) which induces high-frequency high voltage to ionize air and granular particles in exhaust gas, an attractor electrode(**120**) in the nozzle (**105**) which induces high-frequency high voltage to accelerate exhaust gas, a meshed collector electrode(**130**) which partitions granular particles, that is, larger particles drop down into the manhole below the meshed collector electrode(**130**) and small particles are passed through the collector electrode(**130**), and discharge poles(**140**) which burns up the dropped materials in manhole.

Thus the partition unit (**100**) in taking exhaust gas from an engine preliminarily separates exhaust gas into smoke and granular particles and then filters granular particles according to FIG. 2(*a*).

FIG. 2(*b*) shows a brush corona which is discharged form ion pin (**110**) to charge the granular particles in exhaust gas.

FIG. 3(*a*) illustrates a perspective view of partition unit guide assembly(**190**). These assemblies(**190**), as shown in FIG. 1, are arranged in a row and stacked up and down in a casing of the partition unit(**100**). The partition unit(**100**) comprises an ion pin(**110**) and in which occurs brush corona, an air inlet hole(**150**) which takes exhaust gas into a channel, a partition unit guider(**160**) where a bottle-necked nozzle is mounted, a partition unit pole(**170**) which burns up larger particles and which is mounted at discharge poles(**140**) below a collector electrode(**130**) in front of a ion pin(**110**), and partition unit plate(**180**) on which above components are mounted.

FIG. 3(*b*) is a perspective view of the bottle-necked nozzle(**105**) mounted on partition unit guide assembly(**190**). Dissimilarly to FIG. 1 in which only the partition unit guide assembly(**190**) is assembled into the partiton unit(**100**), there can be attached the bottle-necked nozzle(**105**) at the partition unit guide assembly(**190**) as seen from FIG. 3(*b*). As shown in FIG. 2(*a*), the partition unit pole(**170**) may be substituted for ion pin(**110**).

FIG. 4(*a*) shows a unit cell(**250**) of the plasma unit(**200**) which is composed of several unit cells, wherein a plasma unit cell(**250**) comprises several plasma unit poles(**210**) in hemispheric shape which generate streamer corona to burn up the particles passed through the collector electrode(**130**)

of the partition unit(100), several pole holes(220) in which the above plasma unit poles(210) are inserted, meshes (211), not shown in FIG. 4(*a*), which act as a discharge electrode of the plasma unit pole(210) and a ground hole(260) which is connected to the meshes(211). FIG. 4(*b*) shows the streamer corona which is generated between the plasma unit pole(210) in the plasma unit cell(250) and meshes used as an opposite electrode(211). For example, if the unit pole(210) and the opposite electrode(211) are supplied with high voltage such as +10 KV and −10 KV respectively, streamer discharge phenomenon occurs between each pole, namely, unit pole(210) and opposite electrode(211) as shown in FIG. 4(*b*). The electric figure of electron moving status in such a streamer discharge phenomenon is shown in the right side of FIG. 4(*b*).

Plasma is a highly ionized gas in which particles carrying a positive or negative electric charge exist equivalently in a differentiated state and which is of high density and entirely maintains electric neutrality. Especially streamer corona as illustrated in FIG. 4(*a*) is an electric discharge phenomenon in which luminous portions are seemingly mingled with each other between both electrodes. In other words, it is an electric discharge phenomenon in which luminous portions are widened in appearance since fine light flux is gathered together.

In order to utilize such a corona discharge, as shown in FIG. 4(*b*), the plasma unit pole(210) is installed in line with the flow passage of the plasma unit cell(250) and the meshes(211) which may be served as an opposite electrode is installed on the flow passage. On the contrary, plasma unit pole(210) inserted, as shown in FIG. 4(*c*), into the pole hole(220) of the connecting cap(255) mounted vertically to the flow passage of plasma unit cell(250) and opposite electrode(not shown) mounted on the inner periphery opposite to the pole(210) can be used for above corona discharge.

Also, unless the exhaust gas reduction efficiency is required to be maintained at high level, meshes(211) used as an opposite electrode can be removed. This means that although the plasma unit pole(210) is installed in any direction for example, in a vertical, horizontal or reverse direction to the flow passage of exhaust gas, much the same exhaust gas reduction efficiency and capacity can be acquired. Both of the electrodes(210, 211) of the plasma unit cell(250) should be supplied with high-frequency high voltage in order to generate a streamer corona and thus the pointed end of the plasma unit pole(210) is dense with electrons thereby to generate corona plasma such as arc discharge caused by movements of electrons initiated with their inertia force by self-vibration.

As shown in FIG. 5(*a*), the electron unit(300) for burning up minute particles with DC and AC high voltage comprises hole plate(310), ion pin plate(320) and pole-plate(350) as one of unit set having set having same size.

The hole-plate(310) is a plate having a plurality of air inlet holes(330) arranged at regular intervals in every direction and each hole(330) makes the flow of exhaust gas smooth and meshes(211), not shown in FIG. 5(*a*), mounted at the inlet hole(330) makes the flow of electrically charged particles smooth and at the same time acts as an electric discharge electrode.

The ion pin plate(320) applied with high-frequency high voltage is also a flat plate with which a plurality of ion pins(110) are provided at the positions coaxial to the center of the air inlet holes(330) in the same number thereof.

By the way, each ion pin(110) generate a number of electrons thereby to occur an electron wind, which causes a large number of ions to make it easy to capture the particles in the exhaust gas. Thus the ion pin plate(320) should be provided with a plurality of air inlet holes(331) located at the geometrical center of any rectangle formed with 4 ion pins(110) adjacent to each other in every direction in order to make the flow of exhaust gas smooth similarly to above.

The pole-plate(350) equally sized to the hole-plate(310) and ion pin plate(320) has a plurality of plasma unit poles (210) attached to the same location where the ion pin(110) of the ion pin plate(320) is located.

These plasma unit poles(210) are caused to discharge a streamer corona for burning up electrically charged particles captured by themselves. The pole-plate is also provided with a plurality of air inlet holes(332) at the center of any rectangularly positioned 4 unit poles(210) similarly to the plate(320) for the purpose of maintaining a good flowing condition of electrically charged particles.

FIG. 5(*b*) shows the embodiment that the above plates (310, 320, 350) are disposed in a electron unit(300). These plates(310,320,350) as an electrode or an opposite electrode are possible to be installed it any direction such as in a vertical, horizontal or reverse direction against the flow of exhaust gas and the design of these plates can be varied to secure the durability and reliability. Also, both electrodes can be shaped in a various form such as circular, vertical or elliptic type of shape.

Practically, the efficiency of cleaning exhaust gas depends on size, shape, disposition of the plates(310, 320, 350) and applied voltage and current.

The appropriate are of cleaning exhaust gas in a electron unit(300) is characterized by:

S=WNH

wherein distance between plates(310, 320, 350) is W, the height of plates(310, 320, 350) is H, the amount of exhaust gas is L, and the cross-sectional area for cleaning exhaust gas is S, if space is composed of n plates.

The space between plates(310, 320, 350) in a lane, and the area of one lane is 2LH so that the total area of cleaning exhaust gas in a electron unit(300) is as as follows.

A=2NLF

CD-7KV is applied to each ion pin plate(320) and hole-plate (310) to ionize the minute particles by a ion pin(110) on the ion pin plate(320) and then to deposit the ionized particles on the meshes(211) of the hole-plate(310) and to cause electron wind between a ion pin plate(320) and a hole-plate(310).

High voltage pulse of 10 KV is applied to pole plate(350) to generate streamer corona to burn up the particles collected on meshes(211).

FIG. 5(*c*) is a circuit which supplies DC voltage to an ion pin(110) mounted on an ion pin unit plate(320), comprises a transformer(T) to multiply voltage, a rectifying diode (D1, D2), a filtering resistor(R1, R2) to attenuate a ripple signal, a resistor (R3) the time constant of this circuit and capacitor (C1) which determine the time constant of this circuit.

FIG. 5(*d*) is another circuit which supplies DC voltage to an ion pin(110) mounted on a ion pin unit plate(320). A circuit comprises a transformer(T) to multiply voltage, a rectifying diode(D3), resistor(R6) and capacitor(C2) which determine the time constant of this circuit when positive voltage is applied, and resistor(R5) and capacitor(C2) which determine the time constant of this circuit when negative voltage is applied.

Here, electric field(E) generated at a ion pin(**110**)

$$E=\frac{V}{R(RC/RD)}$$

V: voltage applied at a ion pin(**110**)

R: the radius of corona discharge generated at a ion pin(**110**)

RD: the radius of discharging current generated at an ion pin(**110**)

RC: the radius of meshes(**211**) set up on an air inlet hole(**150**).

Referring to FIG. **6**, the ionization unit(**400**) comprises many ionization cells(**405**) composed of an inner pipe(**410**) and an outer pipe(**420**) disposed coaxially to the inner pipe(**410**) where gas passes through at high speed, and a hole-plate(**430**) served as an opposite electrode applied with high vlotage. Both of the inner and out pipes(**410, 420**) are formed into a tapered off cylinder like a syringe.

The hole-plate(**430**) which acts as a opposite electrode can be shaped into a flat plate as shown in FIG. **1** and provided with a plurality of air inlet holes(**431**) which equal in number to the ion pin plate(**320**) of the electron unit(**300**). A plurality of ionization cells(**405**) are attached to the cell plate(**409**) assuming the form of flat plate as seen from FIG. **7** in the case of applying in practice to the exhaust gas cleaning apparatus as shown in FIG. **1** and each ionization cell(**405**) is attached to the location centered on the axis passing through the center of any rectangle formed with 4 adjacent air inlet hole(**431**).

FIG. **8** shows are set of screen unit(**600**) which is composed of several sets. Each set of screen unit has the first plate(**601**) made of ceramic material coated with metal film which is 20–30 μm thick and formed with hexagonal hole (**610**) shaped as honeycomb, depicted in detail by A, to generate UV rays and the second plate(**603**) having PN diode(**620**) inserted into the hexagonal holes(**610**) formed in the same way of the first plate(**601**) in order to remove NOx gas with moisture generated by temperature drop of the exhaust gas. The screen unit(**600**) comprises the first and the second plate(**601, 603**) stacked one by one as a module. At this time, the operating system voltage of the PN diode(**620**) is 0.7 V. Accordingly, the number of diodes which is needed, N, is specified as

$$N=\frac{\text{DC Voltage(V)}}{0.7\text{ V}}$$

FIG. **9**(*a*) shows a high-frequency voltage generator, wherein it comprises a first order coil applied with AC voltage, a transistor(T) to amplify signal, bias resistor(R7) to stabilize operation, a third order coil applied with high voltage according to the turns ratio, a second order coil to modulate carrier having 50 KHz–100 KHz, a voltage multiplier circuit (D5), and capacitor(C5) to charge a third order voltage.

FIG. **9**(*b*) shows a voltage multiplier circuit(D5) in detail shown in FIG. **9**(*a*), which comprises a third order coil to induce high voltage according to turns ratio, diode (D10, . . . D80) to rectify AC voltage, high voltage is charged across capacitor (C5, . . . , C70).

And the equivalent circuit of a voltage multiplier circuit (D5) is shown.

FIG. **10** shows the horizontal section of the union unit (**700**). This unit(**700**) comprises a mechanical-electric filter, to absorb engine noises and to shield electromagnetic waves to be radiated from corona discharge process.

Namely, this unit is used to meet the regulations of EMI, EMC specification of this inventive apparatus. **B4** inserting a plurality of ferrite cores(**720**) into metal house(**710**) and by winding wire (**730**) around ferrite cores (**720**), this unit (**700**) shields EMI and EMC.

To shield EMI, EMC effectively, a wide range L and C with resonant frequency is recommended. A fine ceramic material can be substituted for the metal house(**710**) and ferrite material can be used for the cores(**720**) mounted outwardly to the metal house(**710**).

This ferrite cores(**720**) are divided into 2 groups one of which is operated for a positive magnetic field and another of which is operated for a negative magnetic field so as to shut off the electromagnetic waves found near the exhaust port. Also, as shown in FIG. **11**, the entire external housing is prefered to have an exhaust port bended towrad the ground and is more effective when used duplicately in parallel arrangement.

FIG. **11** shows the entire external form of the present invention, which is housed with metal in order to cut off the outer impact and to prevent irradiating engine noise and electromagnetic waves caused by each unit.

The outlet of the case is forwarded to the ground. The operation of the apparatus in the present invention will be explained in the as follows.

Partition unit (**100**) takes exhaust gas pushed out from an engine and sends it to the plasma unit (**200**) fluidly. In the partition unit (**100**), EHD (electro-hydro dynamics) method is applied between inhaling site (a—a) and exhaling site (b—b) to accelerate the flow of exhaust gas and electrostatic method of Coulomb's force is used. Exhaust gas mixed with air is inhaled into the partition unit (**100**), and the granular particles in exhaust gas are decomposed and ionized into negatively charged particles. The negatively charged particles pass through the bottle-necked nozzle, where the speed of the gas accelerates by means of EHD method.

In addition, negatively charged particles accelerate much more by voltage difference between the ion pin (**110**) and then attractor electrode (**120**) induced negatively, and this phenomenon prevents exhaust gas from staying or slowing down in the partition unit (**100**). We call the above process as EHD (electro-hydro dynamics) method. Exhaust gas after passing thorough the nozzle is diffused to a collector electrode (**130**), where the diffusion theory of wave guide is applied. That is, exhaust gas diffused after passing through a narrow space can spread widely without slowing down of the speed. The negatively charged particles are attracted by electrostatic force on the collector electrode (**130**) which is made of metal mesh and larger particles which can not pass through the collector electrode (**130**) of metal mesh (**211**) drop down into the manhole where one set of discharge poles (**140**) are disposed to burn up large particles.

Large particles in exhaust gas are eliminated by burning up in the manhole where small particles may pass through the collector electrode (**130**). It is preferred that the partition unit pole (**170**) has a round head in shape to increase ignition energy.

The high speed of exhaust gas is helpful in preventing the collector electrode (**130**) from being filled up with small particles.

In the plasma unit (**200**), particles are burned by applying plasma process, that is to say, particles which have been passing through the collector electrode (**130**) are burned up again while passing thorough the plasma cell (**250**), where plasma means that particles are divided into positive and negative particles, of which the amounts are the same, and therefore they show neutral state in total. Small particles

which can pass thorough the collector electrode (130) are burned up in a plasma unit cell (250) by streamer corona generated between a plasma unit pole (210) applied with + voltage and mesh (211) applied with – voltage.

At this time, since the plasma generated at the plasma unit (200) have a tendency to maintain electric neutrality because of their equal density of positive and negative electric charge, when the high voltage is applied to the unit pole (210) and mesh (211) for a short time, particles in exhaust gas flowed into the plasma unit cell (250) are charged and burned up by flame discharge which occurs between a plasma unit pole (210) and mesh (211).

In addition, particles oscillate due to property of attracting each other by electrostatic force and this prevents the meshed net (211) filled up with particles. Further, electrons oscillate in plasma state, and electron's oscillation frequency enhance the particles oscillation.

Oscillation frequency (f_k) is characterized by

$$f_k=8.9\times10^3\sqrt{N},$$

where N is electron density and oscillation frequency depends on air pressure.

Then, the exhaust gas passes through the electron unit (300) is provided with air inlet holes (330) for the exhaust gas to pass thorough uniformly. At this time, meshes such as the meshes (211) can be mounted to the flow passage as a discharge electrode. AC high voltage is impressed between the pole-plate (350) and the hole-plate (310) in order to generate electric wind from ion pin (100) of the ion pin unit plate (320) and thereby to push the particles toward the hole-plate (310). Thus the minute particles passing through the meshes are burned up again effectively by the corona discharge generated between the hole-plate (310) and the pole-plate (350).

The above-mentioned process will be explained systematically in the following.

The noxious materials in exhaust gas are nearly cleared by several steps, wherein large particles are preliminary burned up to be removed in the partition unit (100), and then small particles passed through the partition unit (100) are removed in plasma unit (200) by streamer corona, and then minute particles are eliminated in electron unit (300).

There are noxious chemical materials in exhaust gas, and two different methods are used to remove noxious chemical materials in the present invention.

First, noxious materials are removed with negative ions generated by ionization unit (400). Ionization unit (400) which generates ultraviolet rays between outer pipe (420) and opposite electrode (430), and thus ultra-violet rays generate lots of negative ions.

While the general negative-ion generator has a pointed-end in order to produce negative ions, negative ion generator of the present invention has an ionization cell (405) structure which has inner cylindrical wall dividing the space into two routes, that is, inner pipe (410) and outer pipe (420) in addition to the known form. By the above-mentioned ionization cell (405) structure, the negative ion generator of the present invention emits more negative ions several thousand times than the usual negative ion generator, while the noxious gases pass through at very high speed.

We call this method as plasma jet, where the appropriate distance between outer pipe (420) and opposite electrode (430) should be maintained in order to generate negative ions in a larger amount.

Corona is also generated at the pointed end of plasma jet, and its temperature is 800° C.–1500° C.

The noxious material molecules are excited by ultra-violet rays and the excited noxious materials combine negative ions and ozones to be changed into other materials. And in this process noxious positive ions are also removed.

In order to remove NOx which is not removed in the above-mentioned ionization unit (400), screen unite (600) is used in the present invention.

The screen unit (600) comprises the first place (601) and the second plate (603) having hexagonal holes (610) in which PN diodes (620) are disposed.

When 10 K voltage is impressed to plates, ultra-violet rays are generated around hexagonal hole (610) in a larger amount, and ultra-violet rays let O_2 be changed into ozone.

Ozone is generated in a large amount when thickness of metal is 20 μm–30 μm.

The impedance matching is important, since the printed metal may be separated form ceramic plate, if higher voltage than 1 KV is impressed for a long time.

Also the separation of the printed metal from ceramic plate can be prevented by scratching the ceramic plate.

Such an apparatus has been used for sterilization of food or for generator of ozone, but it has been never used for eliminating of smoke.

In addition, PN diode (620) mounted in hexagonal holes (610) of plate B (640) cause temperature dropping by Sellen's effect to condense H_2O into water.

Ultra-violet rays are generated in a large amount when high voltage is impressed to the coated surfaces of the first plate (601) and the second plate (603) faced to each other, and the ultra-violet rays make oxygen into ozone which renders NOx and NO_3 which can be easily dissolved in water.

During this process, the efficiency of removing NOx will be enhanced by taking air into plates and connecting the PN diodes (620) in serial and parallel arrangement. The method of dropping temperature by using PN diodes (620) is called as Sellen's effect and this method has been used for refrigerator, but has never been used for eliminating smoke.

Most of noxious chemical gas in exhaust gases is removed in the ionization unit (400) and a NOx, which is not filtered in the ionization unit, is removed through the screen unit (600).

Therefore, the granular ingredients and noxious chemical gas of exhaust gases are completely purified.

A high voltage generator with a high frequency comprises by a high frequency oscillator and a high voltage rectifier with transformer.

The high voltage generator with a high frequency of this invention supplies positively and negatively polarized high voltage.

A high voltage generator in the present invention is different form the usual one in the point that it has a special circuit which needs an isolation strength and a feedback circuit to shutdown a first order coil voltage, if a second order coil is abnormal.

This high voltage generator shown in FIG. 9 (*a*) comprises a transistor to amplify a modulated signal, a thirdly order coil to induce a high voltage, a secondly order coil to shutdown a first order coil voltage, when second order coil does not work well, a capacitor (C5) to charge voltage, and a voltage multiplier circuit (D5) to multiply a voltage.

A voltage multiplier circuit (D5) is used to multiply voltage needed for the above-mentioned units (100, 200, 300, 400, 600), wherein E is a charged voltage across a capacitor (C5), 2E is a charged voltage across a capacitor (C10), 3E is a charged voltage across a capacitor (C20), 4E is a charged voltage across a capacitor (C30), 5E is a charged voltage across a capacitor (C40), 6E is a charged voltage across a capacitor (C50), 7E is a charged voltage across a capacitor (C60), 8E is a charged voltage across a capacitor (C70).

A ceramic resistor filter (R100) is used to prevent circuit breakdown, and to avoid dangerous situation which are caused by the remaining high voltage across capacitor (C10, . . . , C70) in case of a third order coil voltage "OFF".

As modulating a carrier (400 KHz) and a signal (50 KHz–100 KHz) at a second order coil, a transistor outputs specially high voltage without excessive current. To reverse an output voltage polarity, the connection of diode (D10, . . . , D80) is reversed.

As E is a charged voltage across a capacitor (C5), discharge voltage (Vo)

$$Vo = \frac{C_1 E}{C_1 + C_2}\left(1 - e\frac{C_1 + C_2}{C_1 + C_2 R_s}(t)\right)$$

This invention can contain a union unit (700), which comprises a mechanical-electric filter, to absorb engine noises and to shield electromagnetic waves to be radiated from corona discharge process.

Namely, this unit is used to meet the regulations of EMI, EMC specification of this inventive apparatus. By inserting ferrite cores into metal house and by winding wire around ferrite cores, this unit (700) shields EMI and ECM.

To shield EMI, EMC effectively, a wide range L and C with resonant frequency is recommended.

As above-mentioned, this invention relates to a method and an apparatus to clean exhaust gas of an internal combustion engine, and external combustion engine and anti-pollution equipment and so on. A this invention can clean exhaust gas and reduce noise, it can be substituted for a noise absorber, for example, the muffler of automobiles.

What is claimed is:

1. A method for cleaning exhaust gas by using a high voltage field, which comprises the successive steps:

(a) partitioning granular particles in the exhaust gas by means of ionizing the granular particles present in the exhaust gas by using electric discharge and then diffusing the exhaust gas at high speed by using a bottle-necked attractor electrode and burning up large granular particles with corona discharge;

(b) burning minute granular particles, which are not removed in step (a), under plasma atmosphere;

(c) further burning the minute particles by using AC voltage and DC voltage;

(d) removing noxious gas component present in the exhaust gas with negative ions generated by an ionization unit; and

(c) oxidizing NO_x present in the exhaust gas with ozone generated by an ultraviolet ray and removing oxidized NO_x by dissolving the same in H_2O generated from heat exchange with PN diodes.

2. A method of cleaning exhaust gas by using a high voltage field as in claim 1, wherein step (a) additionally comprises;

(a') diffusing the thus-ionized particles to a collector electrode (130) at high speed by using the bottle-necked attractor electrode (120);

(a") partitioning the diffused particles, wherein small diffused particles pass thorough the collector electrode (130) and large diffused particles drop down to be deposited in a manhole; and

(a"') burning up the deposited large particles with electric discharge.

3. A method for cleaning exhaust gas by using a high voltage field as in claim 1, wherein the particles in the plasma state in the step (b) are burned up by using oscillary corona discharge.

4. A method for cleaning exhaust gas by using a high voltage field as in claim 3, wherein corona discharge is a streamer corona having a large discharge area.

5. A method for cleaning exhaust gas by using a high voltage field as in claim 1, wherein after step (b), step (c) comprises:

(c') burning up the minute particles by using corona discharge generated by AC voltage; and

(") burning again minute particles which are not burned up in the step (c') by using DC voltage.

6. A method for cleaning exhaust gas by using a high voltage field as in claim 5, wherein corona discharge is a streamer corona having a large discharging area.

7. A method for cleaning exhaust gas by using a high voltage field as in claim 1, wherein the step (d) comprises:

(a) generating a great deal of negative ions; and

(b) decomposing noxious gas by using the negative ions.

8. A method for cleaning exhaust gas buy using a high voltage field as in claim 1, wherein the step (e) comprises:

(a) generating ultraviolet rays;

(b) oxidizing NO_x with the ultraviolet rays; and

(c) dissolving oxidized NO_x in H_2O which is generated by using heat exchange with PN diodes.

9. A method for cleaning exhaust gas by using a high voltage field as in claim 8, wherein the step of generating ultraviolet rays comprises:

(a) printing an electrode circuit pattern with metal on a plate;

(b) printing an electrode circuit pattern on an opposite electrode in a same way; and

(c) supplying high voltage to each electrode for generating ultraviolet rays.

10. A method for cleaning exhaust gas by using a high voltage filed as in claim 9, wherein the electrode circuit pattern on the plate is printed with metal having a thickness of 10 μm–50 μm.

11. A method for cleaning exhaust gas by using a high voltage field as in claim 8, wherein the heat exchange for condensing H_2O is induced by arranging the PN diodes in series or in parallel between plates.

12. Apparatus for cleaning exhaust gas of granular particles and noxious gas competent by using a high voltage field, which comprises is sequence orders:

(a) a partition unit, which takes in the exhaust gas, ionizes particles present in the exhaust gas and then diffuses to a collector electrode where the particles are partitioned, and large particles are burned up with a corona discharge;

(b) a plasma unit, which burns granular particles which pass through the partition unit by using a streamer corona;

(c) an electron unit, which burns gas-borne particles by using AC voltage and DC voltage;

(d) an ionization unit, which removes the noxious gas component by using negative ions; and

(e) a screen unit, which oxidizes NO_x present in the exhaust gas with ozone generated by an ultraviolet ray and removes the oxidized NO_x by dissolving the same in H_2O generated by a temperature drop induced by PN diodes.

13. Apparatus for cleaning exhaust gas as in claim 12, comprising a further union unit in addition to said units,

wherein the union unit shields from electromagnetic waves and reduces noise.

14. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 13, wherein the outer part of said union is formed as ferrite core for shielding electromagnetic wave and an electric field in the air.

15. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 14, wherein said ferrite core is connected in 2 stages serially, of which the first stage is operated in a positive magnetic field and of which the second stage is operated in a negative magnetic field.

16. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 12, wherein said partition unit comprises

(a) as ion pin for ionizing particles with a high voltage to remove particles;

(b) a partition unit guide to provide a smooth flow of exhaust gas;

(c) a partition unit plate with a plurality of air inlet holes to provide a smooth flow of air;

(d) an attractor electrode to supply voltage to a bottle-necked nozzle where the flow of exhaust gas accelerates;

(e) a collector electrode for filtering particles; and

(f) a partition unit pole mounted with discharge electrodes to burn up large particles dropped in a manhole.

17. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 16, wherein the nozzle part acts as an electrode in whole tube.

18. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 16, wherein said partition union pole is in the shape of sphere to enhance ignition of particles.

19. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 12, wherein said plasma unit contains a plurality of plasma unit cells comprising

(a) a plasma unit pole to generate a streamer corona; and

(b) a meshed not to act as discharge electrode.

20. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 19, wherein said streamer corona occurs between said plasma unit pole and said meshed net.

21. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 19, wherein said plasma unit pole is hemispheric and has one side which is flat to cause streamer corona.

22. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 12, wherein said electron unit contains a plurality of sets, wherein one set comprises

(a) an ion pin plate having an air inlet hole mounted with ion pins to generate an electric wind;

(b) a hole plate having an air inlet hole mounted with meshed net which acts as an opposite electrode; and

(c) a pole plate mounted with plasma unit poles generating a steamer corona.

23. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 22, wherein said ion pin plate is a matrix structure comprising

(a) an ion pin to generate electric wind; and

(b) an air inlet hole for smooth air flow.

24. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 22, wherein said hole plate is formed with a number of air inlet holes of meshed net for smooth air flow.

25. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 12, wherein said ionization unit cells generating negative ions and ultraviolet rays by plasma jet formed as a cylindrical outer pipe and cylindrical inner pipe with a sharp pointed-end.

26. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 25, wherein said ionization unit comprises

(a) a cell plate with an ionization cell having a matrix form; and

(b) a hole plate having an air inlet hole in which meshed net is cross-sectionally mounted.

27. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 12, wherein said screen unit comprises a first plate and a second plate and arranged with PN diodes to drop temperature.

28. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 27, wherein each plate has a great deal of polygonal holes for generating ultraviolet rays effectively.

29. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 28, wherein the ultraviolet rays are generated from hexagonal holes when supplying power to the plates.

30. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 27, wherein said first plate and second plate used as an electrode have a plurality of hexagonal holes.

31. Apparatus for cleaning exhaust gas by using a high voltage field as in claim 27, wherein said PN diodes are connected in a serial or parallel to induce a Sellen's effect temperature drop.

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